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EDITORIAL

PASTURAGE IN CEYLON

CEYLON is at present very far from being a pastoral country but given the right type of sheep and cattle it offers great opportunity for the rearing of such if only suitable pastures and fodders be provided. The rainfall of Ceylon is between extremes, not too great on the one hand nor too small on the other, to make the rearing of cattle an impossible proposition and such ranges of temperature according to altitude can be found as to bring this factor into a condition of suitability if indeed we do not say under control. What is wanted is greater facilities for grazing, and this implies not only an area of land available for the purpose as so many seem to think, but, an area bearing the necessary and suitable herbage. What has been done in the improvement of herbage in several great present day pastoral countries like Australia and South Africa makes us see opportunity for such work in Ceylon. Whilst we have not an area of very uniform rainfall which is the ideal of a pastoral country yet much of our Island experiences the effect of two monsoonal rains with an intervening period not too long to give it the disadvantage of a drought. It is only areas in the extreme north-east and south-west where the effects of only one monsoon are of importance, and even here the growth of fodder crops to tide over the dry period is not difficult of accomplishment. Compared to Australia, for instance, Ceylon is fortunate. One-third of that continent has an annual rainfall

of less than ten inches, another third less than twenty, and the remaining area, around the coast, has anything up to one hundred and sixty inches. The average annual rainfall of tracts in Ceylon lies between fifty and one hundred inches.

The provision of pasturage in Australia has been and is, therefore, by no means an easier problem than in Ceylon. Yet what wonderful transformations have been effected thereby in that island continent. *Paspalum dilatatum* a grass introduced into Ceylon over thirty years ago is grown on Government Farms and on those of a very few private individuals, but, in Australia where it was introduced only a few years earlier it has covered areas in New South Wales and Queensland far greater than the size of Ceylon and made a thriving dairy industry possible.

When the Aryan race first sighted Australia it had no flocks and herds as we know them and little pasturage suitable for such. It was the land of the wombat, the wallaby, and the kangaroo; without cattle and sheep at a time when cattle had been in Ceylon for over fifteen hundred years. Today Ceylon imports Australian butter, beef, mutton and even fodder. Australian indigenous plants on careful study did not show the same promise for pasturage as did exotics. Whilst that was so in Australia it would be rash to come hastily to any such decision in Ceylon until all indigenous grasses here have received much more careful consideration. Strains of the same species want investigation to see if there be not some more suited than others to our environment. The possibility of finding leguminous plants suited to our non-calcareous soils is an investigation that must proceed side by side with the study of the grasses. There seems no legitimate reason to believe our pasturage is incapable of improvement.

PASTURE TRIALS AT PERADENIYA

SOME NOTES ON THE GRASSES UNDER TRIAL

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IN this Journal Vol. LXXXI, No. 5, November, 1933 pages 273-282 a general account was given of Ceylon grazing grounds and their improvement. In that article the utilization of indigenous strains for our requirements in Ceylon was strongly stressed. It is now intended to give a preliminary account of the pastures under trial at Peradeniya. They consist mostly of indigenous grasses, although a few exotics are also included.

These pastures were laid down on a six acre block of the old rubber area at the Bandaratenne end of the Experiment Station. The rubber trees except a few left for shade were cut down. The land was ploughed on 16th May, 1933, and cross ploughed on the 25th. It was disc-harrowed on the 31st and again on the 9th June, 1933. The six acre block was divided up into 1/10 acre plots and fenced. The various species of grass and legume were planted on these plots between the 17th June and 26th July, 1933. It will thus be seen that the experiment has been laid down but a very short time; it may however be of interest to follow its progress so far and again later, from time to time. Before laying down the experiment observations on many of the grasses in their wild state had been made and their seed collected.

For the grasses planting was done either by dibbling seed in holes one foot apart in rows so that when the plants came up they would be one foot by one foot apart, or by planting rooted cuttings one foot by one foot apart. In each plot laid down to grass, *Desmodium triflorum* DC. Hin-undupiyali (S.) was planted six inches apart in rows alternating with those of grass. The object of this was to see if it were possible to establish a grass and a leguminous plant together. It is intended in the future to try other leguminous plants. No manuring was done except in the case of the exotic kikuyu grass, (*Pennisetum clandestinum*), obtained from Australia.

1. *Alloteropsis cimicina*, Stapf is an indigenous grass growing abundantly in warm districts. It is also found in India, Burma, Malaya and China. It is a perennial (sometimes annual) tufted grass with erect or decumbent stems one to two feet high.

The grass was established by rooted cuttings. Its growth was poor at first but in about five months it improved and began to set seed. Seeding continued from December, 1933 to March, 1934.

The grass was eaten by cattle. The yield was small. So far it shows some promise as a pasture grass.

2. *Amphilophis pertusa*, Stapf is an indigenous grass which is very common from the sea level up to an elevation of 3,000 feet. It is also found in all warm countries of the Old World extending westward to the Mediterranean region. It is an annual or perennial grass with creeping or ascending stems one to two feet long.

Rooted cuttings were planted. In July soon after planting their growth was poor but within three months they improved very much and continued to grow well with the Desmodium. By January, that is, six months after planting this grass had covered the whole ground and was flowering. The Desmodium interplanted was good but crowded out where the growth of grass was luxuriant. Seeding was very prolific and continued till the end of March, 1934. At this stage when grazing is done it has been noticed that in the wild grass there is a general tendency for the erect seed producing stems to break off readily from the creeping main stems. The plants do not die after seeding but soon after the rains commence the creeping stems close to the ground give out fresh shoots so that under Peradeniya conditions in the wild state this grass is perennial and is expected to be so in a cultivated pasture.

The grass gives a good yield. Cattle eat it readily at all stages of growth. Ferguson [1] considered it "an excellent fodder grass, green or dry". RangaAchariyar [2] remarks: "This is an excellent fodder grass and it grows quickly and stands cutting very well. Cattle eat this grass very well."

It is distinctly promising as a pasture grass.

3. *Apluda mutica*, Linn. is an indigenous grass which is common from the sea level up to an elevation of 4,000 feet, growing on all kinds of soil. It is a common grass in India. It is a perennial with densely tufted, erect straggling stems one to six feet high.

This grass was grown from rooted cuttings. At the start its growth was poor but it improved rapidly and in six months it had practically covered the whole ground with its dense tufts 3 to 4 feet high and was flowering. It kept on setting seed from January to March. As it practically covers the whole area the Desmodium was entirely killed out. Weeds too in its area were choked.

There is some difference of opinion concerning the value of this grass for pasture and fodder. According to Duthie [3] it is a "fairly good fodder when young" and Haines [4] says "Cattle do not eat it". Our observations here, however, are that it is eaten by the indigenous cattle, especially when it is young, while imported breeds such as Sind and Kangayam cattle also readily eat it. This grass gives a good yield and is of fair promise.

4. *Axonopus compressus*, Beauv: "carpet grass" or *poltana* in Sinhalese is a native of Tropical America now naturalised in Ceylon and occurring in abundance from sea level to the highest elevations. It is a common grass in coconut plantations. It is a perennial creeping grass spreading quickly to form a dense covering and attaining a height of six inches to a foot. When it becomes established it kills out other grasses and forms a pure stand.

Rooted cuttings were planted which started well and in six months covered the entire plot with their thick growth killing out the Desmodium. Seed was set from January to March, 1934.

This grass is very readily eaten by cattle and the yield is good. It is a very useful pasture grass.

5. *Brachiaria distachya*, Stapf is an indigenous grass common from sea level up to an elevation of 2,000 feet, especially in the hotter parts of Ceylon. It is also found in India, Malaya, China and Australia. It is a perennial long creeping grass with ascending stems up to two feet long.

It was grown from rooted cuttings. It started fairly well and went on increasing and improving to form a thick mat with dense growth in six months' time when it started flowering. It set seed from January to March. It seems however to suffer a little from drought. The Desmodium was generally killed out by the thick growth of the grass.

It was readily eaten by cattle at all stages of its growth and it gave a very good yield. It is very promising as a pasture grass.

6. *Cenchrus ciliaris* Linn.—African Fox-tail. This grass has been introduced here from Tanganyika. It is found in the tropical and sub-tropical regions of both worlds. It is a perennial grass with the stems erect or ascending up to a height of 2 to 3 feet from a prostrate base.

Seed was sown on 5th July, 1933. Its growth was good from the start and in six months it had produced large clumps about 2 feet across and 3 feet high when it started flowering in January. It set seed from January to March. The growth of Desmodium was poor, occurring only in between the tufts of the grass.

It was very readily eaten by cattle and it gives a very good yield. It is a very promising grass. It has been cultivated at the Jaffna Experiment Station with success.

7. *Cynodon Dactylon* Pers. Arugam-pillu (T).—Bermuda grass, Doub grass, Hariali grass, is an indigenous grass common in the warmer parts of the Island, growing on very poor soils. It is distributed over all warm countries of the world. It is a perennial long creeping grass sending up numerous erect stems up to a foot hign.

It was grown from cuttings. It started well and in six months it had covered the whole area with a uniform dense growth up to six inches high. It set seed from January to March, 1934. The Desmodium was generally killed out.

Cattle eat it very readily but the yield is somewhat small. It appears to be a promising pasture grass.

8. *Cynodon plectostachyum* Pilger, known as star grass in East Africa, is a native of Tropical East Africa. It is a perennial tufted and creeping grass up to 2 feet high and spreading quickly by means of stolons up to 12 feet long.

Seed of this was obtained from Tanganyika in 1933. The seed was of poor quality and only a few plants came up. These however grew vigorously and in six months had produced good growth and began to flower. The plants set seed from January to March, 1934. The Desmodium was killed out.

Cattle eat it readily and the yield is very good. It is very promising as a pasture grass.

9. *Dactyloctenium aegyptium* Richt. is an indigenous grass common in the warmer parts of the Island. It belongs to the warmer regions of the Old World. It is an annual (sometimes perennial) tufted and somewhat spreading plant with decumbent stems 12 to 18 inches high or very short.

The grass was grown from rooted cuttings. It started well and in six months the original tufts had spread to form a more or less uniform mat sending up erect shoots. It started seeding in five months and kept on setting seed till March. Most of the Desmodium was killed out but there was some left.

Cattle eat it and the yield is fair. It may be promising as a pasture grass.

10. *Danthonia semiannularis* R. Br. is a native of Australia, which has been introduced into Ceylon and successfully established at the Government Dairy Farm, Ambepussa. It is a tufted perennial grass up to 2 feet high and grows on poor soil. It stands drought well.

Seed was sown at Peradeniya on 19th June, 1933. About fifty plants were produced but these grew rapidly producing large tufts up to 3 feet high in six months. The plants set seed from January to March, 1934.

The grass was readily eaten by cattle and the yield was good. It is a promising pasture grass.

11. *Digitaria longiflora* Pers. is an indigenous grass common in the low-country and inland. It is fairly widely distributed in the tropical and sub-tropical regions of the Old World. It is a perennial creeping grass with stems 3 to 12 inches high.

Grown from cuttings it started badly but in seven months it produced a thick sward in places. It set seed from February to March, 1934. The Desmodium was generally choked out by the grass.

Cattle eat it readily but the yield is small. It shows little promise of being a good pasture grass.

12. *Digitaria marginata* Link is an indigenous grass which grows on all kinds of soil and is abundant from the sea level up to an elevation of 4,000 feet. It is known in Sinhalese as "gurval". It is widely distributed in the tropical and sub-tropical regions of both hemispheres. It is a perennial (sometimes annual) tufted grass with erect or creeping stems which reach a length up to three feet or more.

Grown from cuttings its growth was good from the start and in six months it had produced large tussocks over 2 feet across and 2 feet high. It flowered and set seed from about 4 months after planting but more generally from January to March. The Desmodium was generally choked out or present in small quantity in between the tufts.

Cattle eat it very readily at all stages of growth and it gives a good yield. It is a promising grass.

13. *Echinochloa colona*, Link is an indigenous grass common in the hotter parts of the Island, particularly in water-logged situations and generally also on rich soils. It is found in all warm countries of the world. It is an annual tufted grass with erect or decumbent stems up to 2 feet high.

Grown from cuttings it started fairly well but its later growth was poor and after six months there were only small tufts about 6 inches high with a spread of six inches when the plants began to flower. The plant set seed from January to March. The Desmodium was good in patches but most of the ground was bare. As a stand of pasture this grass has not so far been a success perhaps because the ground was too poor.

Cattle eat the grass readily.

14. *Eleusine indica*, Gaertn. is an indigenous grass common especially along roadsides. It belongs to the tropics of the Old World from where it has been introduced to the New. It is an annual (sometimes perennial) tufted grass 1 to 2 feet high.

It grew well from cuttings and in six months it had formed clumps about 8 inches high and 8 inches spread above when the plants were setting seed. At this time in January, the older clumps began to dry up starting from the lowermost leaves. This was continuing slowly and even at present the clumps are alive with outermost leaves dried up. The Desmodium occurred sparsely in between the clumps. When young this is eaten by cattle but after seeding they do not care for it. Its yield here was small.

It is not a promising grass.

15. *Eragrostis pilosa*, Beauv. is an indigenous grass common in the warmer parts of the Island from sea level up to an elevation of 6,000 feet, generally occurring gregariously in wet places. It is widely distributed in Southern Europe and in most warm countries. It is an annual densely tufted grass 6 to 24 inches high.

Grown from cuttings growth was very poor throughout and in six months there were only small tufts. It set seed in four months in November, 1933 and continued to do so till March, 1934. The Desmodium was present only in little patches here and there.

Cattle eat this grass readily when young but after flowering they do not much like it. The yield was very small. This would seem to be of little use as a pasture grass.

16. *Eragrostis tenella*, R. & S. is an indigenous grass common throughout the Island particularly in over-grazed areas. It is found in Tropical Asia and in Tropical and Southern Africa. It is a slender annual tufted grass with decumbent stems 6 to 18 inches high.

Seed was sown on 19th June, 1933. Growth was poor throughout and in 8 months there were but small tufts of the grass. It set seed from December, 1933 to March, 1934. The Desmodium showed fair growth between tufts of the grass.

It is eaten by cattle but the yield is very small so that it would seem of little use for pastures.

17. *Ischaemum ciliare*, Retz. is an indigenous grass common throughout the Island. It is known in Sinhalese as Rat-tana. It is widely distributed in the plains and lower hills of India, in the Nicobar Islands, Malaya, China and Australia. It is a perennial creeping grass, spreading rapidly by its long creeping stems.

Seed was sown on 19th June, 1933. Only a few plants came up but these grew well and spread fairly widely. It set seed from January to March. The interplanted Desmodium was good and seems to grow well with this grass.

Cattle eat it readily and the yield is fairly good. It is a promising grass for pastures in Ceylon.

18. *Ischaemum timorense*, Kunth is an indigenous grass very common from sea level up to 2,000 feet, especially in moist and shady situations. It is known in Sinhalese as Rila-rat-tana. It is found in Bengal, Central India, Burma and Malaya. It is a perennial long creeping grass with ascending stems up to 18 inches high.

Grown from cuttings it started fairly well and went on improving to form a thick mat with ascending branches 1 to 2 feet high in six months' time when it began flowering. It set

seed from January to March. Seeding was very prolific. Desmodium between the plants was generally killed out.

The grass is readily eaten by cattle at all stages of growth and gives a good yield. It is a promising grass.

19. *Hemigymnia javanica* Alst. is an indigenous grass common in the hotter parts of the Island. It is found also in Burma, Malaya and the Pacific and Mascarene Islands. It is an annual or perennial grass with creeping or ascending somewhat tufted stems six inches to two and half feet long.

Growth was good from the start, from cuttings, and in six months' time there was an uniformly thick dense growth. It set seed from January to March, 1934. The Desmodium was killed in places where the grass was thick but in other places it showed good growth.

Cattle eat this readily but not so readily as they eat "carpet grass" (*Axonopus compressus*). It gives a good yield and is a promising pasture grass.

20. *Oplismenus compositus* Beauv. is an indigenous grass common throughout the Island especially in jungles and other shady places. It is widely distributed in all warm countries except Australia. It is a perennial creeping grass with ascending stems up to three feet high.

Raised from cuttings its growth was poor throughout and in six months it had produced a sparse matted growth with numerous ascending branches. It set seed from January to March. The Desmodium showed poor growth even on the bare areas.

Cattle eat it but do not seem to care much for it. Its yield is small and it appears to be of little use for pastures in Ceylon except perhaps in jungles.

(*To be continued.*)

Renanthera Coccinea Lour
(Scarlet Scorpion Orchid)

NOTES ON ORCHIDS CULTIVATED IN CEYLON

RENANTHERA COCCINEA LOUR
(SCARLET SCORPION ORCHID)

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THIS handsome orchid is a native of Cochin China and appears to have been introduced into Ceylon about the year 1884. Unlike the other members of the genus *Renanthera*, it is a very slow though hardy climber and rarely exceeds six feet in length. It is parasitic and thrives upon the trunks of trees in the woods of its native country. The plant sends out long, large, thick fleshy roots at the nodes at irregular intervals. The stem is straight, woody, yellowish green and as thick as the small finger. The leaves are some 3 to 4 inches long and about 1 to 1½ inches broad, thick, fleshy, emarginate at the apex and closely placed.

The flowers are borne on a long spreading scape arising from a node and bearing numerous scarlet pale-yellow mottled blooms on a many branched panicle. The flowers are about 2½ inches in diameter with obtuse lateral petals.

At the early stage of growth the plant requires a certain amount of care and attention for its successful cultivation. Small cuttings with a couple of roots may be placed in perforated pots in a compost of crocks, charcoal, decayed wood, chopped coconut husk and Sphagnum moss, and supported to pieces of thick cuttings of some tree with fleshy bark. When the plants have attained a height of 2 to 3 feet they may be transferred to fair-sized well-drained tubs or to the ground specially prepared for their reception. In the latter case the ground should be dug

to a depth of about 18 inches and all soil removed. A six-inch layer of drainage material having been placed at the bottom, the remainder should be filled with the above mixture. Each plant should be given a couple of living supports planted on the sides, such as cuttings of *Plumeria*, *Jacaranda*, *Peltophorum* or any similar hardy plants that are likely to strike root in the compost. The cuttings of both orchid and their hosts need copious supplies of water at least till they show new growth. The buds of the host plant should occasionally be removed unless they are absolutely necessary to produce shade in a season of severe drought. Long-stemmed plants in flower, which have lost their basal leaves may be cut off at the leafy base and potted for decorative purposes. Removing cuttings from such plants will encourage the leafless stem to emit shoots at the nodes and these serve for further multiplication of the plant.

VERNALIZATION

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THERE has appeared recently an account of work in Russia that is of considerable scientific interest and that may prove to be of great practical importance, if the Russian results can be substantiated and applied to agricultural practice. Briefly, the report announces the discovery of a method of pre-treatment of seed before sowing whereby the period subsequently taken by the plant to come to maturity is lessened without its yield being adversely affected. If it can be applied to agricultural practice it will have considerable results at least in the Temperate Zone, for it will mean that the advantages of early sowing will be attained under conditions where actual sowing in the field would be impossible owing to the presence of snow or to the low temperature, and will thus make possible, if not an extension of cultivation into higher latitudes, at least a more intensive cultivation in those regions where the present growing season is very short.

The Russians call the new process "Jarovizatzia", referred to in German publications as "Jarowisation", but in English the term is replaced by its Latinized equivalent "Vernalization". Its application is based on the distinction between the two phenomena of (1) the growth, or increase in weight and size of a plant, and (2) development, or the transition of the plant through successive phases, in its life history apart from mere vegetative growth. These phenomena are, or can be made to be, independent of one another.

"Under artificial conditions in a greenhouse it is possible arbitrarily to accelerate or retard reproduction by varying the conditions of light, darkness, temperature, humidity, etc. according to the specific requirements of each plant. Under ordinary field conditions this is not the case, and the vegetative period of a plant depends mainly upon the natural conditions of the regions in question. Hence in any particular area only those plants whose vegetative period is such that seed formation falls within the limits of the external factors characteristic for the region are suitable for cultivation. The essence of the method

of vernalization is the elimination of the effect of natural geographical and climatic factors limiting the introduction into field cultivation of any desirable plant''.

It is emphasized by the Russian workers ''that the transition to the reproductive stage is not only independent of the size and age of the plant, but is not correlated in time with growth. The plant may change qualitatively in a required direction without continuing to grow and *vice versa*, the plant may grow and yet not effect the required qualitative change. The processes of vernalization are independent of growth but connected with the environment; if the external condition be favourable both for growth and qualitative change in the plant, the plant will grow and pass through the stages preparatory to reproduction. *The fact that the process of preparation of a plant towards reproduction may occur in the embryo and may be separated in time from the growth of the plant makes possible the practical application of the method of vernalization*''.

The principles of vernalization have been applied to plants associated with tropical and sub-tropical regions as well as to plants of temperate climates. Tropical and sub-tropical, or ''short-day'' plants as they are called, require a combination of high temperature and short daily period of light for reproduction. It is stated that short-day plants require light for the processes of growth and darkness for reproduction, and that the influences are exerted by light and darkness themselves and not necessarily by an alternation of the two. If therefore the plant can at some stage of its development be given a concentrated dose of the darkness factor, it will require no further period of darkness to enable it to pass through the reproductive phase. This is done by forcing the seed to grow and then artificially stopping its growth, after which it is subjected to the influence of the appropriate external factor. ''Thus the sowing material, represented by the pre-treated seed, may have the appearance agronomically of seed, but from this new point of view it should be regarded as seedlings''. In actual practice, the seed is made to germinate by soaking in water, and is then subjected to darkness for a certain time at a certain temperature. The amount of water used, the time kept in darkness and the temperature are all adjusted so that germination is strictly controlled, and that the actual growth is as little as possible. It is necessary to deter-experiments have been made with maize, sorghum, Sudan grass mine by experiment the details for each crop but preliminary

and soya bean and it has been found that plants raised from pre-treated seed have flowered appreciably before control plants. The technique for rice has not been worked out.

There are striking points of similarity in the above process and the methods used by the Sinhalese paddy cultivator and it is interesting to speculate whether the goiya has unconsciously anticipated the Russian scientists. Before sowing his fields, the paddy cultivator soaks his seed in water for 12 to 24 hours, then wraps it up in gunny bags or plantain leaves and leaves it for six to eight days to germinate after which it is sown. The reason given for germination is that seedlings are more quickly and easily anchored in the mud of the field and are not so likely to be washed away or concentrated in lowlying parts of the field as would be seed; and the reason for putting under pressure is that germination is thereby hastened and the resulting seedlings are more evenly germinated. There is no deliberate attempt to exclude light from the heap, yet it is almost inevitable that light should be excluded, and there are thus created all the conditions that are said to be necessary for vernalization. Is it not then possible that the villager's seed is being vernalized and that seed of the same variety sown dry at the same time would take appreciably longer to come into ear ? Experiments are in hand to determine these points, and of them an account will be given in due course. It should be stated that the temperatures reached in a heap of paddy seed under pressure are much higher than any that have been hitherto determined for the vernalization of tropical crops, and that the amount of water used for soaking in the Russian experiments is much less than the amount the seed will absorb; nevertheless, the general methods are so similar that it would be surprising if similar results were not achieved.

On the other hand should further shortening of the vegetative period be possible by suitable treatment, it may be that a high yielding Maha strain of paddy may be made to mature, without loss of yield, in the space of a Yala season, or that a high yielding strain of whatever age may be introduced into a tract where it could not otherwise be grown on account of a slight difference in age. These questions remain to be investigated.

For information on the principles and methods of vernalization I am indebted to Bulletin No. 9 of the Imperial Bureau of Plant Genetics, from which I have quoted freely.

PADDY MANURIAL EXPERIMENTS BURMA*

[The following results with organic manures are extracted from the Department of Agriculture, Burma, Bulletin No. 29 which is a Report on Manurial Experiments carried out in Burma by the Agricultural Department complied by R. Watson, Deputy Director of Agriculture, Burma. To those further interested the full Bulletin is recommended for study.—Ed. T.A.]

A crop in Burma prior to 1912 a comprehensive experiment was designed to answer the following questions:—

(i) Whether the rice plant requires its nitrogen in the organic, ammoniacal, or nitric form.

(ii) Whether phosphates, potash and lime were required.

The method of experiment adopted was to apply varying quantities of farmyard manure alone, farmyard manure in combination with minerals, and finally minerals alone. The plots were long and rectangular in shape and each treated plot had a corresponding control or untreated plot opposite to it.

Subsequent investigation has shown that this method of experiment, while good enough for observational purposes, is unsuitable for exact quantitative work. It however served a very useful purpose in throwing a good deal of light on the requirements of the rice plant and has enabled similar additional work to be considerably narrowed down. The experiment was laid down at Hmawbi farm in 1913-14 and carried on for five years, after which period residual effects were ascertained for a further period of five years.

This experiment was duplicated at the Mandalay farm where paddy is grown under irrigation.

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MANURIAL TRIALS AT HMAWBI FARM

Average yield over five years

Treatment rates per acre yearly	Yield per treated plot (lb.)		Control (lb.)		Average increase or decrease per cent. on Control (Grain)
	Grain	Straw	Grain	Straw	
(1)	(2)	(3)	(4)	(5)	(6)
1. Cattle manure 30 lb. N_2	194	320	160	228	+21
2. Cattle manure 50 lb. N_2	215	363	165	270	+30
3. Cattle manure 70 lb. N_2	242	433	148	239	+63
4. Cotton cake 50 lb. N_2	218	413	154	270	+41
5. Cattle manure 30 lb. N_2 Superphosphate 20 lb. P_2O_5 Sulphate of Potash 20 lb. K_2O	216	416	143	227	+51
6. Cattle manure 30 lb. N_2 Superphosphate 20 lb. P_2O_5	202	421	138	230	+46
7. Cattle manure 30 lb. N_2 Bone meal 20 lb. P_2O_5	213	414	142	222	+50
8. Bone meal 20 lb. P_2O_5	178	317	140	221	+27
9. Superphosphate 20 lb. P_2O_5	190	353	134	211	+42
10. Potassium Sulphate 20 lb. K_2O	148	275	129	216	+15
11. Nitrate of Soda 30 lb. N_2	116	207	124	209	− 6
12. Nitrate of Soda 30 lb. N_2 (top dressing).	147	251	124	200	+18
13. Nitrolim 30 lb. N_2	151	279	126	205	+20
14. Sulphate of Ammonia 30 lb. N_2	187	365	127	204	+47
15. Lime 2,000 lb.	175	321	127	203	+37
16. Ammonium Sulphate 30 lb. N_2 Superphosphate 20 lb. P_2O_5 Sulphate of Potash 20 lb. K_2O	208	427	124	198	+68

The layout in this experiment does not admit of a true estimate of standard error, the chief difficulty being the want of replications. General conclusions may, however, be drawn from a study of the figures:

(1) Organic manures, especially farmyard manure, give a considerable increase and may be safely recommended.

(2) The greater the application of nitrogen the greater the yield of grain.

(3) Nitrogen in the ammoniacal form is the most effective. This is followed by organic nitrogen, while nitrogen applied as nitrate of soda gives poor results.

(4) Superphosphate shows a distinct increase in the yield.

(5) Potash does not appear to be of any great importance as a paddy manure in Lower Burma.

The residual effects were ascertained for the five years 1918-19—1922-23; but as the figures are not complete for all the control plots results are not quite accurate and are therefore not recorded.

A general analysis of the figures, however, indicates that plots Nos. 11, 12, 13 and 14 which were treated with nitrate of soda, sulphate of ammonia and nitrolim, respectively, gave lower mean yields than their respective controls.

MANURIAL TRIALS AT MANDALAY FARM

Average yield over five years

Treatment rates per acre yearly	Yield per treated plot (lb.)		Control (lb.)		Average increase or decrease per cent. on Control (Grain)
	Grain	Straw	Grain	Straw	
(1)	(2)	(3)	(4)	(5)	(6)
1. Cattle manure 30 lb. N_2	115·0	197·2	84·3	120·6	+ 35·7
2. Cattle manure 50 lbs. N_2	121·5	225·4	80·3	112·9	+ 51·3
3. Cattle manure 70 lb. N_2	135·3	259·1	82·8	127·4	+ 63·4
4. Cotton cake 50 lb. N_2	121·9	211·6	98·3	161·3	+ 24·0
5. Cattle manure 30 lb. N_2 Superphosphate 20 lb. P_2O_5 Sulphate of potash 20 lb. K_2O	132·4	236·2	103·8	190·6	+ 27·5
6. Cattle manure 30 lb. N_2 Superphosphate 20 lb. P_2O_5	144·6	231·1	105·4	167·2	+ 37·2
7. Cattle manure 30 lb. N_2 Bonemeal 20 lb. P_2O_5	129·8	214·1	77·0	118·0	+ 68·5
8. Bonemeal 20 lb. P_2O_5	96·0	156·0	64·8	92·5	+ 48·1
9. Superphosphate 20 lb. P_2O_5	103·7	155·8	41·9	59·8	+147·2
10. Sulphate of potash 20 lb. K_2O	61·2	94·9	42·5	66·3	+ 44·0
11. Nitrate of Soda 30 lb. N_2	63·2	80·2	48·7	65·6	+ 29·8
12. Nitrate of Soda 30 lb. N_2 (top dressing)	71·6	95·2	52·1	69·3	+ 56·6
13. Nitrolim 30 lb. N_2	97·8	143·6	63·6	84·0	+ 53·7
14. Sulphate of Ammonia 30 lb. N_2	75·4	98·1	52·6	69·6	+ 44·0
15. Lime 2,000 lb.	53·5	71·4	47·1	63·4	+ 13·5
16. Ammonium Sulphate 30 lb. N_2 Superphosphate 20 lb. P_2O_5 Sulphate of Potash 20 lb. K_2O	116·0	176·0	45·1	58·5	+157·2

As in the Hmawbi experiment the want of replications does not admit of a true estimate of standard error.

A study of the figures however gives the following indications:

(1) Cattle manure alone gives appreciable increases in yields and can be recommended with safety.

(2) Among the nitrogenous manures sulphate of ammonia does not stand out clearly as in the Hmawbi experiment.

(3) Superphosphate alone and in combination with sulphate of ammonia and sulphate of potash gives high increases although when applied with cattle manure, the increased yield is not outstanding.

(4) Sulphate of potash gives indications of being more necessary than in Lower Burma.

Residual Effects.—These were studied for two or three years but the fluctuations from year to year, owing to insect attack, etc., rendered the results difficult of interpretation. The main indications were chemical manures leave little residue after the first year but that the heavier dressings of farmyard manure show up for two or three years.

INDIGENOUS MANURES (PADDY)

In addition to the plots treated with indigenous manures in the Hmawbi and Mandalay permanent series, which have been discussed, a number of trials have been carried out on the newer paddy farms at Myaungmya, Mudon and Akyab. The results of these are given and may be compared with the Hmawbi and Mandalay ones.

FARMYARD MANURE

Akyab.—The experiment was part of one in which lime and a complete dressing of artificial fertilizers were tested along with farmyard manure.

The trial was commenced in the year 1925-26, just after the opening of the farm, and continued for three years, in order to find the effect of farmyard manure on poor paddy soil. Figures for straw are not available as the straw was not harvested during the first two years and unexpected rain prevented proper weighment in the third year.

Rotation.—Normal, *i.e.*, paddy yearly.

Plots.—5 acre. Rectangular in shape.

Replications.—Three.

Scatter.—No randomization. Plots arranged in regular order.

Year (1)	Treatment (2)	Average yield of grain per acre (lb.) (3)	Average increase per cent. on control (4)	Standard error per cent. on control (5)	Significance (6)
1925-26	Control	1253·6	—	—	—
	Farmyard manure 50 lb. N_2 per acre	1611·66	+28·5	5·38	5·3
1926-27	Control	1464·84	—	—	—
	Farmyard manure 50 lb. N_2 per acre	1769·84	+20·8	5 16	4·0
1927-28	Control	1083·4	—	—	—
	Farmyard manure 50 lb. N_2 per acre.	1244·6	+14·9	8·3	1·8

Conclusions.—The increases in yield although significant over the controls for the first two years amount to an average annual increase of some 21 per cent. only compared with 30 per cent. at Hmawbi for a similar dressing and 34·9 per cent. at Mandalay for a dressing of 40 lb. N_2 per acre. As no analysis of the manure was made it cannot be definitely concluded on the result of this trial, that farmyard manure has a less beneficial effect on paddy at Akyab than it has at Hmawbi or Mandalay.

SOME OTHER TRIALS.—SYNTHETIC FARMYARD MANURE

Synthetic farmyard manure was manufactured at Hmawbi farm in 1924. After preparing for three months it was found to contain ·592 per cent. of nitrogen. The experiment was designed as follows:—(i) synthetic farmyard manure at 50 lb. N_2 per acre, (ii) ordinary farmyard manure at 50 lb. N_2 per acre, (iii) straw in quantity per acre equivalent to that used in the manufacture of the synthetic farmyard manure, (iv) ammonium sulphate and calcium carbonate in quantities per acre equivalent to that used in the manufacture of the synthetice farmyard manure.

The total net increases in grain over the control for the different treatments are as follows:

Synthetic farmyard manure 34·67 per cent., ordinary farmyard manure 35·1 per cent., straw 18·9 per cent. $(NH_4)_2SO_4 + CaCO_3$ 26·47 per cent. It would appear that for the paddy crop the increase in yield from synthetic farmyard manure is very similar to that from ordinary farmyard manure though from the economic point of view the additional cost of manufacturing the synthetic product places it at a distinct disadvantage.

BATS' GUANO

Bats' guano is produced in the Province but is not easily obtainable except in the immediate localities of the deposits. Its scarcity and high cost render it of little importance as a manure for paddy, so only two trials are recorded.

The manure used showed an analysis 7·40 per cent. Nitrogen (N_2), 3·41 per cent. P_2O_5 and 1·02 per cent. Potash (K_2O).

It had been ascertained from previous observation trials that the manure is an extremely active one and caused a strong leafy growth and tendency to lodge late in the season.

Year	Treatment	Avearge yield per acre.		Average increase or decrease per cent. on control (Grain)	Standard error per cent. on control	Significance
		Grain lb.	Straw lb.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Control	1,874	4,236	—	—	—
	30 lb. N_2	2,245	4,933	+20·0	—	3·8
1924-25	50 lb. N_2	2,326	5,450	+24·0	—	4·6
	70 lb. N_2	2,271	5,593	+21·0	5·23	4·0
	Control	1,105	2,874	—	—	—
1925-26	30 lb. N_2	1,197	2,762	+ 8·3	—	1·07
R.E.	50 lb. N_2	1,376	3,488	+25·0	—	3·22
	70 lb. N_2	1,197	2,960	+ 8·3	7·76	1·07

Applications at a rate to give 30 lb. nitrogen per acre showed an increase of 20 per cent. of grain over the control and at a rate of 50 lb. of nitrogen per acre 24 per cent.

Bats' guano gives significant increases in yield but the high cost and small amounts available prevent its competing with other manures for the paddy crop.

RICE BRAN, HMAWBI FARM, 1928-30

Rice bran is produced in large amounts locally and if obtainable at a low price would be of considerable value as a manure.

The demand for this bye-product for other purposes is however too strong to allow of its being utilised as a manure.

In this experiment coarse rice bran was applied at the rate of 20 lb. nitrogen per acre in 1928 and the residual effect ascertained during 1929 and 1930. The nitrogen content was ascertained by the Agricultural Chemist to be 1·93 per cent.

The conclusions arrived at were that as a manure rice bran is of value but the price at which it is normally sold does not make its use an economic one.

Conclusions.—Significant increases on the controls are indicated at Hmawbi and Myaungmya. As a manure rice bran is therefore of value if obtainable at a much cheaper rate than that at which it is mornally sold.

FISH MANURE, HMAWBI FARM, 1926-30

Fish manure is an indigenous manure made chiefly in Mergui, in the Tenasserim Division of Lower Burma.

It is a comparatively costly manure and not easily available except where produced. Chemical analysis showed a nitrogen content of 4·065 per cent. and a relatively high percentage of P_2O_5.

Two series of plots were manured in 1926 and the residual effect ascertained during the four succeeding years.

The manure was applied at 10, 20 and 30 lb. N_2 per acre.

Conclusions.—Fish manure appears to have a stimulating effect on the paddy crop in the year of application. A very considerable residual effect is also apparent though the yields shown in this experiment are somewhat irregular. The high cost of the manure prevents its general use as a fertilizer.

WATER HYACINTH (EICHHORNIA CRASSIPES) COMPOST, MYAUNGMYA FARM, 1928-29 TO 1930-31

The water hyacinth has spread very rapidly in most of the waterways of Burma and an experiment was commenced at Myaungmya Farm in 1928-29 to ascertain the value of water hyacinth compost as a fertilizer for paddy.

The following method was adopted in the preparation of the compost. The hyacinth was collected in October and after sundrying for ten days an 18-inch layer was put into an enclosure measuring 15 ft. × 12 ft. A similar

layer of cowdung and earth, in the ratio of 6:3, was added and the whole thoroughly mixed. The process was repeated until a height of 5 feet had been reached. Thorough mixing was then done monthly until May when the compost was applied to the plots.

An analysis of the compost by the Agricultural Chemist showed:

Total Nitrogen	...	...	0·269 per cent.
P_2O_5	...	...	0·208 per cent.
K_2O	...	...	0·759 per cent.

Compost was applied at the rate of ten tons per acre, equivalent to 59 lb. N_2 in 1928-29, and the residual effect ascertained for the two succeeding years.

Rotation.—Normal, *i.e.*, paddy yearly.

Plots.—165 feet × 10 feet. Rectangular in shape.

Replications.—5 = 10 plots.

Scatter.—Manured plot alternate with control.

Year	Treatment	Avearge yield per acre. Grain (lb.)	Straw (lb.)	Average increase or decrease per cent. on control Grain	Standard error per cent. on control	Significance
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1928-29	Control	1,071	1,902	—	—	—
	Manured	1,762	2,853	+59·0	5·1	11·6
1929-30	Control	1,632	3,180	—	—	—
K.E.	Manured	2,043	4,015	+25·2	2·48	10·16
1930-31	Control	1,085	2,921	—	—	—
R.E.	Manured	1,204	2,521	+11·0	10·11	1·1

Remarks.—No abnormal tillering or incidence of pest or disease attack noted.

Conclusions.—The increase in yield recorded is significant over the controls for the first and second years and would indicate that where labour is cheap the manufacture of water hyacinth compost should be encouraged.

GREEN MANURE (ISCHAEMUM LAXUM)

HMAWBI, 1925-26 TO 1927-28.

"Myetni" (Ischaemum Laxum) grows freely on the Hmawbi farm paddy area and the following experiment was designed to test its value as a green manure alone and in combination with superphosphate, on an area of heavy stiff clay where the crop was generally poor. The layout included

controls, "Myetni" alone, superphosphate alone, and "Myetni" *plus* superphosphate. Superphosphate was applied at the rate of $2\frac{1}{2}$ cwt. per acre.

Rotation.—Normal, *i.e.*, paddy yearly.

Plots.—12 feet × 165 feet = $\frac{1}{32}$ acre.
Replications.—4 = 16 plots.

Scatter.—No randomization, plots arranged in regular order.

Year	Treatment	Average yield per acre		Average increase or decrease per cent. on control	Standard error per cent. on control	Significance.
		Grain (lb.)	Straw (lb.)	Grain		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Control	1,518	2,926	—	—	—
	Superphosphate	1,738	3,212	+14·5	—	1·45
1925-26	"Myetni" alone			+ 5·9	—	·59
	"Myetni" + Superphosphate	1,826	3,696	+20·3	10·0	2·03
	Control	1,687	3,201	—	—	—
1926-27	Superphosphate	1,949	3,471	+15·5	—	3·69
R.E.	"Myetni" alone	1,949	3,643	+15·5	—	3·69
	"Myetni" + Superphosphate	2,068	3,667	+27·6	4·2	6·57
	Control	1,566	2,744	—	—	—
1927-28	Superphosphate	1,375	3,491	−12·2	—	1·4
R.E.	"Myetni" alone	1,643	2,542	+ 4·9	—	0·56
	"Myetni" + Superphosphate	1,698	4,092	+ 8·4	8·7	0·96

General Conclusions.—The increases in yield due to treatments, though high, are not statistically significant.

LIME, HMAWBI FARM, 1927-30

Previous trials carried out in 1919 and 1924 in which lime had been applied at the rates of 2,000 lb. and 6,000 lb. per acre respectively indicated that such heavy dressings were not advisable or profitable.

Results noted below are for an experiment, commenced in 1927 and carried on till 1930, in which a dressing of 560 lb. per acre, of magnesium free lime was given in the first year and the residual effects studied in the following years:

Rotation.—Normal

Plots.—165 feet × 16 feet = $\frac{1}{16}$ acre. Rectangular in shape.

Replications.—4 = 8 plots

Scatter.—Alternate control and treated.

Year	Treatment	Average yield per acre		Average increase or decrease per cent. on control	Standard error per cent. on control	Significance.
		Grain (lb.)	Straw (lb.)	Grain		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1927	Control	803	1,224	—	—	—
	Limed	843	1,259	4·9	15·5	·32
1928	Control	1,376	2,571	—	—	—
R.E.	Limed	1,659	3,176	20·6	4·9	4·2
1929	Control	1,408	2,448	—	—	—
R.E.	Limed	1,465	2,656	3·4	8·37	·4
1930	Control	1,598	2,706	—	—	—
R.E.	Limed	1,608	2,936	·62	2·31	·3

Conclusions.—This trial was carried out on a "bad patch" of the farm and although a total gain of 29 per cent. in grain yield has resulted no definite conclusions can be drawn. Further experiments with different amounts of lime will be carried out.

LIME PLUS CATTLE MANURE

To find the effect of lime when applied along with cattle manure on the paddy crop.

Lime was applied at varying rates from 5 cwt. to 60 cwt. per acre in conjunction with a non-varying application of farmyard manure equal to 50 lb. N_2 per acre. The plots were treated in 1927-28 and residual effects studied over the next three years.

Conclusions.—Increases in yields in the first year are very considerable and would indicate that lime may be applied at rates of up to 40 cwt. per acre on soils of this type.

Residual effects show progressive increases up to treatments of 40 cwt. per acre for the second and third year while in the fourth year treatments above 10 cwt. per acre show a falling off in yield.

INHERITANCE OF CHARACTERS IN RICE*

INTRODUCTION

THIS paper deals with studies on the inheritance of the following characters in rice: Length of glumes, absence of ligules, brittleness, shattering, dwarfness, awns, color of awns, color of glumes, color of apiculi, and earliness.

LENGTH OF GLUMES

Most varieties of rice (*Oryza sativa* L.) have short (outer) glumes. The glumes usually vary in length from one-fifth to one-third of that of the lemma and palea. However, in some varieties the glumes are nearly as long, or quite as long, as the lemma and palea. These long-glumed varieties are reported to be resistant to lodging and shattering. They are not grown on a commercial scale in the United States.

Parnell et al. and Kato and Van der Stok, according to Ikeno, obtained in F_2 populations plants with short and long glumes in a ratio of 3:1. Chao, in a cross between a glutinous long-glumed variety and a common short-glumed variety, obtained in F_2 a ratio of 15 plants with short to 1 plant with long glumes. In this case short glumes were due to dominant duplicate genetic factors. Ramiah et al. in a cross between short and long-glumed varieties, obtained F_1 plants that had glumes intermediate in length between the parents. In the F_2 populations the parental and intermediate glume lengths were obtained. These investigators placed the F_2 plants with respect to glume length in three groups, namely short, intermediate, and long, and by this arbitrary grouping they obtained approximately a 1:2:1 ratio. However, there was much variation in the length of the glumes of plants classified as intermediate. In this group the glumes varied in length from almost as short as the short-glumed parent to nearly as long as the long-glumed parent. This indicates that the plants classed as intermediate for glume length were not genetically similar and suggests that the difference between the short-glumed and the long-glumed varieties probably was due to multiple factors.

In 1926 Yosemite, a normally short-glumed variety, was crossed with "Nimai Kawa Mochi" and "Weitin", long-glumed varieties. The parents and F_1 plants were grown in 1927. The spikelets of F_1 plants from both crosses had normal short glumes.

In the F_2 population of the cross Yosemite × Nimai Kawa Mochi 1,116 plants were grown to maturity. Of these 831 plants had spikelets with short glumes and 285 plants had spikelets with long glumes. These numbers agree with a monohybrid 3:1 ratio, the deviation being only $6{\cdot}00 \pm 9{\cdot}76$ plants. Of the 1,047 Yosemite × Weitin F_2 plants 785 had

* By Jenkin W. Jones, Senior Agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture in *Journal of Agricultural Research*, Vol. 47, No. 10, November 15, 1933.

short glumes and 262 had long glumes the deviation from a 3:1 ratio being 0 25±9 46 plants. In the total F_2 population of the two crosses there were 1,616 plants with short glumes and 547 with long glumes, the deviation from a monohybrid ratio being 6·25 ±13·59 plants.

Fifteen random F_2 progenies from the cross Yosemite × Nimai Kawa Mochi and 16 progenies from the cross Yosemite × Weitin were grown in the F_3 Of the 15 progenies, 7 segregated for short and long glumes, 3 bred true for short glumes, and 5 bred true for long glumes. Of the 16 progenies, 7 segregated for short and long glumes, 4 bred for short glumes, and 5 bred true for long glumes. The results for both groups are shown in table 1.

Table I.—Breeding behaviour of F_2 progenies from the crosses Yosemite × Nimai Kawa Mochi and Yosemite × Weitin grown in F_3 a the Biggs Rice Field Station, Biggs, Calif., 1929.

Cross	Number of progenies	Number of plants with glumes		Deviation from 3:1 ratio and probable error
		Short	Long	
Yosemite × Nimai Kawa Mochi	3	605	—	— —
	7	904	297	3·25 ±10 10
	5	—	837	— —
Yosemite × Weitin	4	704	—	— —
	7	964	346	18·50 ±10 54
	5	—	765	— —
Total for 14 segregating progenies		1,868	643	15·25 ± 14·63

In the seven segregating progenies of each cross producing plants with short and long glumes the deviations from 3:1 ratio were less than twice the probable error in all progenies, except for one in each cross. The results show that short glumes are dominant to long glumes and that the long-glumed and short-glumed varieties used in this study differ by a single genetic factor for this character.

ABSENCE OF LIGULES

In commercial rice varieties the ligules at the juncture of the leaf blade and sheath are usually well developed. A liguleless variety, "Tsutsuito", the only one known to the writer, was obtained in Japan in 1925. Tsutsuito is late-maturing, liguleless, and awnless. It was crossed with "Kotake", also late-maturing, and partly awned.

The F_1 plants had normal ligules and were partly awned like the male parent Kotake. An F_2 population, consisting of 1,024 plants was grown in 1927. Of this number 796 plants had normal ligules and 228 were liguleless, the deviation from 3:1 ratio being 28·00 ± 9·35 plants.

Fifteen random F_2 progenies were grown in the F_3 in 1928, of which 6 consisting of 989 plants, bred true for normal ligules, 5 segregated and gave 655 plants with ligules to 195 without ligules and 4 consisting of 725 plants, bred true for the liguleless character.

The five progenies that segregated in F_3 produced 655 plants with and 195 plants without ligules, the deviation from 3:1 ratio being $17{\cdot}50 \pm 8{\cdot}51$ plants. According to Ikeno, Kato found that normal ligules were dominant to the liguleless character in rice. He obtained in F_2 3 plants with normal ligules to 1 without ligules.

BRITTLENESS

The culms and leaves of commercial rice varieties vary in strength and toughness. Under normal conditions some varieties do not lodge, whereas others lodge badly. Between these two extremes there are various degrees of resistance to lodging. However, all the commercial varieties are normal in that the straw possesses a certain degree of toughness or tensile strength and is somewhat resistant to complete breaking by bending or twisting. In contrast to the normal toughness of the culms and leaves of the commercial varieties is the extreme brittleness of the culms, leaves and other parts of "Kama Irazu" a variety obtained in Japan. This variety does not lodge, although the stalks bend over under the weight of heavy panicles. However, in both the green and the mature stages the leaves and culms are so brittle that they break off at the slightest pressure. The writer was informed that the name Kama Irazu means "no need of a sickle in harvesting". This variety was so named because a standing plant gathered into the hand snaps off when given a slight twist. The panicles also are brittle and the spikelets fall off easily. In threshing, the lemma and palea often are removed and the kernel is easily broken.

In the cross Kama Irazu × Colusa (C.I [3] 1600, a normal variety) the F_1 plants had normal (not brittle) stalks, leaves, and panicles. In the second generation there were 479 plants with normal stalks, leaves and panicles to 156 plants with these parts brittle. The deviation from a 3:1 ratio was $2{\cdot}75 \pm 7{\cdot}36$ plants. The segregation into normal and brittle plants was very distinct. The ordinary green rice leaf often can be folded up without breaking into separate parts, but the brittle leaf is easily snapped off when bent. Owing to this fact it was possible to classify the plants even before they headed.

Twenty-five random F_2 progenies were grown in the F_3. Six of these, consisting of 292 plants, bred true for normal plants; 14 segregated, producing 453 normal plants to 142 brittle ones; and 5, consisting of 223 plants, bred true for the brittle character. The segregation of each of the 14 progenies agreed well with a ratio of 3 normal plants to 1 brittle plant, the deviation for the 14 progenies being $6{\cdot}75 \pm 7{\cdot}12$ plants.

Analyses were made of the straw and grain of Kama Irazu and of Colusa (C.I. 1600). The straw of Kama Irazu contained less ash, silica, and crude fiber than that of Colusa, but a higher percentage of lignin, nitrogen, and moisture. The chemical data do not show the cause of brittleness in Kama Irazu, but this character may be due to cell structure or arrangement.

SHATTERING

Varieties differ greatly with respect to the tightness with which the grain is held on the panicle before and after maturity. In certain varieties the grain is held so tight that threshing is difficult. In others the grain shatters very easily, even when carefully handled. Between these two extremes there probably are varieties representing all degrees of tightness.

In the United States commercially grown rice varieties are more or less resistant to shattering but do not hold the grain so firmly that they cannot be satisfactorily threshed with modern machinery. Varieties that shatter too easily are not suited for harvesting with grain binders. In countries where rice is harvested by hand and threshed by treading and flailing, varieties that shatter rather easily are grown in preference to those that shatter less readily.

Takenouchi reports that at the juncture of the rice grains and their supporting stalks there is a special tissue consisting of from 1 to 3 layers of lignified thin-walled cells. In rices that shatter easily these cells develop and dry up early, whereas in rices that shatter less easily they do not dry up so early.

According to Matsuura, Kato crossed a non-shattering rice with one that shattered easily. In the F_1 the plants were non-shattering and in the F_2 the ratio of non-shattering plants to those that shattered easily was 3:1.

The Caloro and Colusa varieties, which are extensively grown in California, do not shatter easily if properly handled. These were crossed with Chinese varieties that shattered easily. The crosses were C.I. 7075 × Colusa, C.I. 7078 × Caloro, and C.I. 7389 × Caloro.

The F_1 plants of these crosses of these plants appeared to be intermediate. They did not shatter so readily as did the Chinese varieties, and yet they did not seem to hold the grain quite so firmly as did Colusa and Caloro.

Owing to various degrees of sterility in the F_2 plants of these crosses and to the failure of many individual plants to mature grain, only part of the F_2 population was suitable for a study of the inheritance of shattering.

On the basis of the ease or difficulty of stripping the grains from the mature panicles of plants standing in the field, it was not hard to determine relative resistance to shattering. Only a few trials were necessary to reduce this determination to a fair degree of accuracy. The plants from which it was easy to remove the seed were classed as easily shattered, whereas those from which it was rather difficult to remove the seed were classed as non-shattering.

In the F_2 population from the cross C.I. 7075 × Colusa there were 29 non-shattering plants to 11 that shattered readily; from the cross C.I. 7078 × Caloro there were 99 non-shattering plants and 46 that shattered readily; and from the cross C.I.7389 × Caloro there were 249 non-shattering plants and 109 that shattered readily. In each cross these numbers agree reasonably well with a 3:1 ratio. The deviations from this ratio in the order given were 1.00 ± 1.85 plants, 9.75 ± 3.52 plants, and 19.5 ± 5.53 plants. The results that in the varieties used in this study the non-shattering and shattering characters probably differ by a single genetic factor.

DWARFNESS

Dwarf varieties of rice often are grown at rice experiment stations. While they are of no economic importance, they are of interest to plant breeders. According to Ikeno a dwarf rice plant was described by Iwasaki in 1828.

Parnell et. al first reported on studies of the inheritance of dwarfness in rice. They found that dwarfness is a simple recessive to normal. The average height of the normal parent used in their study was 49·7 inches and that of the dwarf parent 27·9 inches. The average height of the normal segregates in F_2 was 50·5 inches and of the dwarf segregates 31·2 inches.

Sugimoto states that dwarfness usually is a simple recessive to normal. He found a dwarf mutant in a true-breeding normal variety, Waseshinriki, which was a simple recessive to normal. Another dwarf appeared as a mutant in a true breeding strain isolated from a hybrid. This dwarf was dominant to normal and in the F_2 segregation produced 3 dwarf plants to 1 normal.

Akemine crossed the normal variety Akage with the dwarf varieties "Daikoku" and "Ebisu". In the F_2 segregation both crosses produced 5 normal plants to 1 dwarf. In a cross between the dwarf varieties Daikoku × Ebisu the F_1 was normal and the segregation in F_2 gave 9 normal to 3 Daikoku to 3 Ebisu to 1 new very short dwarf type, Kodaikoku. Akemine assumed that the genetic constitution of normal was AABB, Ebisu AAbb, Daikoku aaBB, and Kodaikoku aabb.

Nagai reported a dwarf mutant that was recessive to normal. This mutant showed a peculiar mode of inheritance in that in successive generations mutant individuals gradually increased in proportion to normals.

The writer obtained in Japan seed of a dwarf variety known as "Daikokune". This variety was short, rather wide, erect leaves, short culms, and a short compact panicle that looks more like a spike of wheat than a panicle of rice. It is partly awned and the kernel is short and round and enclosed by a rather coarse hull. The cross Yosemite × Daikokune was made in 1927. Yosemite is an early maturing, awnless variety of normal height.

The F_1 plants were intermediate in maturity, partly awned, normal in appearance, and somewhat taller than the normal parent. The average height of the normal parent was 38 inches, of the dwarf parent 14 inches, and of the F_1 plants 43 inches. The average length of 10 panicles of the normal variety was 4·7 inches, of the dwarf parent 2·3 inches, and of the F_1 plants 4·6 inches.

The F_2 population consisted of 677 plants that were grown to maturity of which 547 were normal and 130 were dwarf. Segregation into the two groups was very distinct. The deviation from 3:1 ratio was 39·25 $\pm$ 7·60 plants, or more than five times the probable error, whereas the deviation from 13:3 ratio was only 3·0625 $\pm$ 6·85 plants. However the segregation of random F_2 progenies grown in F_3 shows that the 3:1 ratio is correct.

In the F_2 population the average height of 100 normal segregates was 37·4 inches and the average height of 100 dwarf segregates was 16·9 inches. The average height of 42 plants of the normal variety was 32·6 inches and the average height of 42 dwarf plants was 13·9 inches. The normal and dwarf segregates in F_2 exceeded the normal and dwarf parent varieties in average height. Of 25 random F_2 progenies grown in 1930, 7 consisting of 367 plants, bred true for normal stature, 15 segregated for normal and dwarf plants, and 3, consisting of 86 plants, bred true for

dwarf plants. Each of the 15 segregating progenies produced normal and dwarf plants in numbers that agreed well with a 3:1 ratio. The total for the 15 progenies was 598 normal to 181 dwarf plants, the deviation from a 3:1 ratio being $13{\cdot}75 \pm 8{\cdot}15$ plants. In the varieties used in this study dwarf character was a simple recessive to normal.

AWNS

Rice varieties may be classed as fully awned, partly awned, and awnless. In fully awned varieties all spikelets are awned but the awns often vary in length. In partly awned varieties, awned and awnless, spikelets are present on the same panicles. In true awnless varieties the awns are absent and do not develop under any conditions. In some varieties the main panicle may be awnless, whereas some of the spikelets on branch culms and later tillers may be partly awned. The extent of development of the awns in rice is controlled by climatic conditions and soil fertility as well as by genetic factors. In some crosses it is difficult to separate the awn types because climatic conditions and soil fertility have such a marked influence upon their development.

Chao, Hoshino, Jones, Mendiola, Nagai, Yamaguchi, and Kato and Van der Stok, according to Matsuura have reported that in F_1 awns are dominant or partially dominant to the awnless character in rice. A segregation in F_2 of 3 awned or partly awned plants to 1 awnless plant has been reported by Jones, Nagai, and Chao, and a ratio of 9 fully awned to 6 partly awned to 1 awnless plant by Jones. The awned group in the 15:1 ratio reported by Chao were designated as fully awned, mostly awned and rarely awned plants.

In the few crosses between fully awned and awnless varieties that have been studied by the writer, three groups of awned plants have been observed in the F_2 segregations. These are fully awned plants, partly awned plants with awns about the same length as in fully awned plants but present only on part of the spikelets on a panicle, and partly awned plants with short awns often confined to the spikelets near the tip of the panicles. The plants in this last group may be referred to as tip-awned. It appears that fully awned varieties often differ from awnless varieties by two independent genetic factors. If this is true the fully awned group from a cross between a fully awned and an awnless variety should differ from the partly awned and tip-awned groups by a single genetic factor, and the partly awned group should differ from the tip-awned group by two genetic factors. Data in support of this view are reported herein.

AWNLESS X FULLY AWNED

In the cross Colusa (awnless) × Aikoku (fully awned) the F_1 plants were partly awned. In the F_2 segregation 607 plants were classed as fully awned, partly awned and tip-awned to 71 awnless plants. The deviation from a 15:1 ratio in this case is $28{\cdot}63 \pm 4{\cdot}25$ plants. This deviation is very large.

Twenty-five random F_2 progenies were grown in F_3. Five progenies produced 225 fully, partly, and tip-awned plants to 13 awnless plants. These numbers agree in those expected in a 15:1 ratio, the deviation being $1{\cdot}88 \pm 2{\cdot}52$ plants. Six progenies, consisting of 309 plants, produced fully awned, partly awned, and tip-awned plants in what appeared to be a

ratio of 3 fully awned to 1 partly awned, and 3 partly awned plants to 1 tip-awned. However, the awn types in this cross could not be separated with certainty. Ten progenies produced no fully awned plants, but 347 partly awned and tip-awned plants to 120 awnless plants, deviating from a 3:1 ratio by $3{\cdot}25 \pm 6{\cdot}31$ plants. One progeny, consisting of 46 plants, appeared to be fully awned, and three progenies, consisting of 119 plants appeared to produce only partly awned or tip-awned plants. The number of random F_2 progenies was too small to yield all the possible segregations and true breeding groups that were expected. However, the results, suggest that the fully awned variety Aikoku probably differs from the awnless variety Colusa by two main genetic factors for awns.

PARTLY AWNED X FULLY AWNED

In the cross Caloro (partly awned) × Butte (fully awned) the F_1 plants were fully awned. The segregation for awns was not studied in F_2, but a study was made of the segregation of 11 random F_2 progenies grown in F_3. Each of the 11 F_2 progenies and the total of the 11 progenies produced fully awned and partly awned plants in a ratio of 3:1. In the 11 F_2 progenies there were 393 fully awned to 99 partly awned plants, the deviation from a 3:1 ratio being $24{\cdot}00 \pm 6{\cdot}48$ plants. This deviation which is more than three times the probable error, was probably due to errors in classifying the plants resulting from the natural variability of awn development. In the individual progenies there were 3 small plus deviations, 7 minus deviations, and one progeny with no deviation from the 3:1 ratio.

PARTLY AWNED X AWNLESS

Colusa, Chinese Originario, Maratelli, and Yosemite, awnless varieties, were used as female parents in crosses with Wataribune and Caloro, partly awned varieties. Yosemite, Chinese Originario and Colusa were crossed with Wataribune, Yosemite and Chinese Originario, and Maratelli was crossed with Caloro. In each of the six crosses the F_1 plants were partly awned.

Table 2.—F_2 segregation of crosses between awnless and partly awned rice varieties grown at the Biggs Rice Field Station, Biggs, Calif., 1929.

Cross		Nnumber of F_2 plants			Deviation from 3:1 ratio and probable error
Female awnless	Male partly awned	Partly awned	Awn-less	Total	
Yosemite	Wataribune	450	199	649	$36{\cdot}75 \pm 7{\cdot}44$
Chinese Originario	do	421	121	542	$14{\cdot}50 \pm 6{\cdot}80$
Colusa	do	251	94	345	$7{\cdot}75 \pm 5{\cdot}42$
Chinese Originario	Caloro	473	161	634	$2{\cdot}50 \pm 7{\cdot}35$
Yosemite	do	423	178	601	$27{\cdot}75 \pm 7{\cdot}16$
Maratelli	do	484	184	668	$17{\cdot}00 \pm 7{\cdot}55$

The F_2 segregation of the six crosses is shown in table 2. In all crosses the number of partly awned and awnless plants agrees well with a 3:1 ratio, except for the crosses Yosemite × Wataribune and Yosemite × Caloro. The deviations in these crosses are large and suggest the possibility of a modifying factor in the Yosemite variety.

25 random F_2 progenies from the crosses Yosemite × Wataribune, Chinese Originario × Wataribune, Colusa × Wataribune and Chinese Originario × Caloro were grown in F_3. The breeding behaviour of these progenies is shown in table 3.

Table 3.—Breeding behaviour in F_3 of F_2 progenies from crosses between awnless and party awned rice varieties grown at the Biggs Rice Field Station, Biggs, Calif., 1930.

Cross		Number of F_2 progenies grown in F_3	Number of F_3 plants		Deviation from 3:1 ratio and probable error
Female, awnless	Male, partly awned		Partly awned	Awnless	
Yosemite	Wataribune	3	142	—	
		16	605	153	36·5 ± 8·04
		4	—	197	
Chinese Originario	do	6	258	—	
		13	494	136	21·50 ± 7 33
		4	—	170	
Colusa	do	7	349	—	
		11	446	168	14·50 ± 7·24
		7	—	360	
Chinese Originario	Caloro	11	550	—	
		11	429	121	16·50 ± 6·85
		2	—	100	

In each cross three or more F_2 progenies bred true for partly awned plants and two or more bred true for awnless plants. Of the F_2 progenies that segregated in F_3 all produced partly awned and awnless plants in a ratio of 3:1, except one or two progenies in each cross. The failure of some segregating F_2 progenies to give the expected 3:1 ratio may have been due to errors in classification or possibly to natural crossing in F_1 as the F_1 plants were not bagged. The fact that nearly all the F_2 progenies gave the expected 3:1 ratio in F_3 indicates that the partly awned and awnless varieties used, with the possible exception of Yosemite, probably differ by a single genetic factor.

The data on the inheritance of awns in crosses between an awnless and fully awned variety, a partly awned and a fully awned variety, and awnless and partly awned varieties indicate that the fully awned varieties differ from Colusa, awnless, by two independent genetic factors. Butte, fully awned, appears to differ from Caloro partly awned by a single genetic factor and Caloro and Wataribune, partly awned, appear to differ from the awnless varieties by a single genetic factor.

COLOR OF AWNS, GLUMES, AND APICULI AWNS

AWNS

Aikoku has red awns, glumes, and apiculi, whereas Colusa is awnless and has green apiculi and glumes which are straw-coloured at maturity. In the cross Colusa × Aikoku the F_1 plants had red awns, glumes and apiculi. In the F_2 population 454 plants had red awns and 153 plants had green awns. These numbers agree well with 3:1 ratio, the deviation being only $1{\cdot}25 \pm 7{\cdot}20$ plants.

Of 25 random F_2 progenies grown in F_3, 4 consisting of 185 plants, bred true for red awns; 13 produced 392 plants with red awns to 126 plants with green awns; 3 progenies, consisting of 133 plants, bred true for green awns; and of 5 remaining F_2 progenies, 3 consisting of 141 plants, segregated for red awned and awnless plants with red glumes and apiculi, and 2, consisting of 97 plants, segregated for green-awned and awnless plants with green glumes and apiculi. Each of the 13 F_2 progenies that segregated for red and green awns did so in a ratio of 3:1. In the 13 prigenies as a group the deviation from a 3:1 ratio was $3{\cdot}50 \pm 6{\cdot}65$ plants, which is a satisfactory fit.

Caloro is partly awned and has green awns and glumes. In the cross Caloro × Aikoku the F_1 plants had red awns and glumes. In the F_2 population there were 402 plants with red awns to 261 plants with green awns. These numbers are in fair agreement with a 9:7 ratio. The deviation was $29{\cdot}0625 \pm 8{\cdot}62$ plants. Of the F_2 population, 663 plants were classed as awned and 15 as awnless. One random F_2 progeny, which was classed as awnless in F_2, was partly awned in F_3. Therefore, it is probable that other plants classed as awnless in F_2 carried factors for awns but that owing to environmental conditions no awns were visible.

Of the random F_2 progenies grown in F_3, 4 consisting of 202 plants, bred true for red awns, 5 produced 143 plants with red awns to 105 plants with green awns, 9 produced 269 plants with red awns to 90 plants with green awns; and 7, consisting of 301 plants, bred true for green awns. The deviation from a 9:7 ratio for 5 of the F_2 progenies was $3{\cdot}50 \pm 5{\cdot}27$ plants, which is a satisfactory fit. The deviation from a 3:1 ratio for 9 of the F_2 progenies was $0{\cdot}25 \pm 5{\cdot}53$ plants, or almost a perfect fit.

Butte is a fully awned variety with red awns. In the cross Caloro × Butte the F_1 plants had red awns. In the segregation in F_2 271 plants had red awns to 251 plants with green awns. In this case the deviation from a 9:7 ratio is $22{\cdot}625 \pm 7{\cdot}64$ plants. Twenty random F_2 progenies were grown in F_3. Four consisting of 168 plants, bred true for red awns; 4 produced 91 plants with red awns to 63 plants with green awns, or in a ratio of 9:7; and 12 progenies consisting of 560 plants bred true for green awns.

In the cross Colusa × Aikoku the difference in awn color apparently was due to a single genetic factor, whereas in the crosses Caloro × Aikoku and Caloro × Butte the difference appeared to be due to two complementary genetic factors. The results indicated that Colusa has one complementary

genetic factor in common with Aikoku and Butte. However, Caloro appears to differ in awn color from Butte and Aikoku by two complementary genetic factors.

GLUMES AND APICULI

Aikoku has red glumes and Colusa has green glumes.

In the cross Colusa × Aikoku the F_1 plants had red glumes. Segregation for color glumes in F_2 gave 504 plants with red glumes to 174 plants with green glumes. The deviation from a 3:1 ratio is $4{\cdot}50 \pm 7{\cdot}60$ plants.

Of the 25 random F_2 progenies grown in F_3, 7 consisting of 326 plants bred true for red glumes; 13 produced 450 plants with red to 163 plants green glumes; and 5 consisting of 230 plants, bred true for green glumes. Each of the 13 F_2 progenies that segregated for glume color produced plants with red and green glumes in a ratio of 3:1. The deviation from this ratio for the 13 F_3 progenies was $7{\cdot}25 \pm 7{\cdot}29$ plants.

In the cross Caloro × Aikoku, green by red glumes, the F_1 plants had red glumes. In F_2 the segregation for color of glumes gave 410 plants with red glumes to 268 with green glumes. The deviation in this cross from a 9:7 ratio was $28{\cdot}63 \pm 8{\cdot}71$ plants. In the crosses Colusa × Aikoku and Caloro × Aikoku the color of the apiculi was always the same as that of the glumes and appeared to be controlled by the same genetic factor or factors.

The red glumes of Aikoku differ from the green glumes of Colusa by a single genetic factor and from the green glumes of Caloro by two dominant complementary genetic factors. The same is true of the color of the apiculi of these varieties. In all hybrids studied the color of the apiculi of the lemma and palea was the same as that of the awns. However the writer knows of one variety with red apiculi, the awns of which are green at maturity.

COLOR OF LEMMA AND PALEA FURROWS

The cross Yosemite × Weitin, used in the study of glume length also presented an opportunity to study lemma and palea furrow color. In Weitin the lemma and palea furrows are yellowish brown, and in Yosemite they are straw colored at maturity. In F_1 plants of the cross Yosemite × Weitin the furrows were yellowish brown. Of 1,047 F_2 plants 834 had yellowish-brown and 213 had straw-colored lemma and palea furrows. These numbers agree well with a 13:3 ratio, with yellowish brown dominant to straw color, the deviation from the 13:3 ratio being $16{\cdot}69 \pm 8{\cdot}52$ plants.

Segregating F_3 progenies were not classified for color of the lemma and palea furrows. It was observed, however, that the 7 F_2 progenies segregating for short and long glumes also segregated for color of lemma and palea furrows. Three of the 4 F_3 progenies that bred true for short glumes had yellowish-brown lemma and palea furrows, and the other family segregated for furrow color. One of the 5 F_3 progenies that bred true for long glumes had yellowish-brown lemma and palea furrows, one progeny segregated for furrow color, and three progenies bred true for long glumes with straw colored lemma and palea furrows.

The factors for yellowish-brown color of the lemma and palea furrows and the factor for short glumes appear to be inherited independently, as shown in table 4.

Table 4.—Phenotypes observed and calculated number of F_2 plants in each group from the cross Yosemite × Weitin, grown at the Biggs Rice Field Station, Biggs, Calif., 1928.

Phenotype	Observed	Calculated	$\frac{(O-C)^2}{C}$
Short glumes, yellowish-brown lemma and palea furrows.	637	638·04	0
Short glumes, straw-colored lemma and palea furrows	148	147·24	0
Long glumes, yellowish-brown lemma and palea furrows	197	212·68	1·16
Long glumes, straw colored lemma and palea furrows	65	49·08	5·16
	1,047	1,047·04	—

EARLINESS

In the cross Colusa (an early variety) × Wataribune (a late variety) the F_1 plants and Wataribune matured on October 4 and Colusa on September 19. In the F_2 population there appeared two quite distinct groups with respect to maturity, namely, early and late. On September 6 the early plants were fully headed and starting to mature whereas the late plants were just coming into full heading. On this date the F_2 plants were classified as early and late on the basis of stage of development. There were 264 late to 81 early plants, the deviation from a 3:1 ratio being $5{\cdot}25 \pm 5{\cdot}42$ plants.

Twenty-five random F_2 progenies were grown in F_3. Six progenies, consisting of 232 plants, bred true for late maturity, 12 progenies that segregated for late and early plants produced 485 late to 186 early maturing plants, and 7 progenies, consisting of 341 plants bred true for early maturity. The deviation from a 3:1 ratio for the 12 segregating progenies was $18{\cdot}25 \pm 7{\cdot}57$ plants.

Other studies and observations on the inheritance of earliness in rice have indicated that multiple factors often are involved. It is of interest, therefore, to note the simple segregation in this case. The factorial situation for this as well as for other characters in rice varies with the varieties used.

SUMMARY

The rice crosses used in these studies were grown for three generations except those used in a study of shattering.

In the varieties studied short glumes were dominant to long glumes. The characters normal ligule, normal culm strength, and non-shattering were found to be simple dominants to absence of ligules, brittleness of culm, and shattering of grain, respectively.

The dwarf variety studied was recessive to the normal.

In the crosses awnless × fully awned, partly awned × fully awned, and partly awned × awnless varieties, the data indicate that the fully awned varieties used differ from awnless varieties by two genetic factors, fully awned varieties differ from partly awned by a single genetic factor, and partly awned varieties differ from awnless varieties by a single dominant genetic factor.

In these studies red color in the awns, glumes, and apiculi was dominant to green (straw color). Ratios of 3:1 and 9:7 were obtained, which show that the color was due to a single genetic factor and to two complementary genetic factors.

In Weitin brownish-yellow lemma and palea furrows appeared to be inherited independently of long glumes. The brownish-yellow color of lemma and palea furrows was dominant to straw color and appeared to be due to two genetic factors resulting in a 13:3 ratio.

Plants from the cross Colusa × Wataribune were obtained in the ratio of 3 late to 1 early.

SOME ASPECTS OF SOIL EROSION*

THE question of soil erosion has, during the last few months, figured fairly largely before the general public but it is no new problem.

Erosion and loss or wastage of soil have gone on in this country ever since human occupation or cultivation became at all fixed. In the early times the damage appeared small and the new land available almost endless, but with the increase of population and activity the available new areas soon became limited and the losses were forced on notice. There is no doubt that at the present time erosion and loss of soil have reached the stage of becoming a serious menace in the Union. It is a menace that the Government has decided to tackle seriously. A comprehensive scheme has been put forth for collecting information, education of the public, combating the evil by assisting land owners with loans for reclamation and finally, by assisting research in the fundamental aspects. It is not at all necessary to go into any details of this national scheme. The press has already contained accounts. It is enough to emphasise that the very existence of such activity on the part of the Government is evidence that the problem is a serious one.

The erosion of soil, except in exceptional cases, only occurs when the vegetation covering the surface is destroyed or interfered with. In uninhabited regions the surface is remarkably stable. Soil erosion is thus basically a botanical problem.

The soil is the source of water and food materials for plants and also their foothold. The plants which build up the vegetation form the basis on which ultimately the whole continuance of the human race depends.

The soil consists of broken rock material and is penetrated by roots. These roots keep the soil mass together and increase its mass by penetrating deeper, working into cracks, and so on. In the soil physical and chemical changes go on and organic matter derived mainly from plants, is added, till finally the surface layers become very different both in structure and content from the rocks or rock material from which the soil was originally formed. While the vegetation is untouched and active the formation of soil continues, sometimes rapidly, at others very slowly; but as soon as the plants are removed or destroyed the loose soil material is exposed to easy removal by wind, water or other agents.

In a country such as South Africa, where practically the whole is liable to extended periods of drought and where so much of the rain when it does come falls in heavy storms, erosion is especially liable to occur. The heavy rain falling on dry soil wets and loosens the surface and runs downhill. Unless the soil is held firmly by roots the sudden downhill movement of large quantities of water is liable to remove whole sheets from the surface. In other cases where the water runs off in channels, dongas, which

* By R. S. Adamson in *The Journal of the Botanical Society of South Africa*, Part XIX—1933.

may attain considerable depth, are cut out. These dongas cause great wastage of soil and themselves are a source of drying out of surrounding soil that often results in the death of plants and hence further wastage.

It is not proposed in the present note to attempt any sort of general account of the position in regard to soil erosion in the country but rather to treat very shortly some of the special aspects present in the South-Western Cape region. This region differs in many ways from the remainder of the Union and in any scheme covering the whole country is apt to have its own problems treated as of minor importance in accordance with its proportion of area to the whole. For this reason these local problems are brought forward.

The South-Western Cape is characterised by the rainfall being wholly or in very large part confined to winter months and the summer dry. Correlated with this climate the vegetation is very characteristic, being typically bush, not very tall, and generally with hard evergreen leaves predominantly of small size. Grasses and any turf-forming plants are infrequent or absent and hence grazing is not carried on to any large extent. The main agricultural value of the region is in fruit growing and grain production. The country is mountainous and the land of agricultural value is confined to the lower slopes and valleys and the coastal plain. In this region the losses due to soil erosion are less obvious than in many other parts but are none the less severe.

Erosion is worst on the mountains and as these are of little agricultural value, the loss has, up to the present, been either totally neglected or treated as of no serious account. It is true that the mountain vegetation, which is composed of bushes and reeds, is of little value as food for animals, and the soils too steep, too shallow and often too poor to justify cultivation. In an attempt to create pasturage the practice of burning the vegetation has gone on for centuries. Burning was carried out even before the advent of the white man, who has continued the habit. Several reasons are brought forward in support of the practice. The untouched bush is thick and most of the plants hard and woody. Animals find little to feed on and in the old days were liable to attack from easily concealed leopards or natives. When the bush is burned a certain number of the plants sprout up from underground portions that survive and the young soft shoots are much more palatable than the old hard ones. The apparent improvement is, however, of short duration. After two to four years, depending on local conditions, a dry bush cover, generally of low stature, is established. Not at all infrequently this re-established bush is again burnt in the hope of getting further improvement. But such recurrent fires, especially when combined with grazing, soon eliminate all but tough resistant plants of no economic value at all.

Fire destruction has other effects as well, effects that may mean serious ultimate loss. Fires most commonly occur in summer and especially towards the end of the dry season when both bush and soil are dry. After the fire the soil, which may have been much heated, is exposed to the full drying effect of the sun and wind. This alone causes rapid alteration and often total disappearance of the organic matter in the soil which seriously reduces its nutritive value for plants and its capacity to

hold water. The pale colour of the soils of recently burnt areas must be familiar. Under thick bush the surface layers of the soil are dark, often black, while after a fire the colour changes to white or very pale. This impoverishment of the soil by loss of organic matter renders the reappearance of the plants slower and more difficult.

The unprotected soil of a burnt area is exposed to erosion by wind or water. In the dry season winds remove the loose dry soil, especially in the upper portions of the mountains. When soil in large quantity becomes open to movement by wind action the establishment of plants may become very slow or even impossible.

Water in the form of rain is still more potent as an agent for erosion. The soil, no longer held by roots is washed down the slopes which may become so denuded that the solid rock alone remains; a condition too often seen on our mountains and especially in those with the heaviest rainfall.

After burning the vegetation is regenerated but the vigour of the new growth, its character, and the time taken for it to be formed, depend on the local conditions and the amount of erosion. Even under favourable conditions, when little soil removal occurs, the destruction has an adverse effect. One example must suffice, taken from an area that has been under observation for a number of years. This was on a granite soil on the slopes of Table Mountain. The angle of slope was not sufficient to allow of serious erosion. Before the fire the soil was covered by a dense growth of bushes beneath which were a number of shade tolerant species. Ninety-three different species were recorded of which fifty-one were woody plants. After the fire thirteen of these sprouted from still living underground portions; the remainder either restarted from seed or were totally destroyed. The area was kept under observation for seven years, during which time no further fire took place. At the end of the period the vegetation, as compared with the original, was lower and less dense. It contained a larger proportion of low growing woody plants with small leaves. The shade enduring plants, which have relatively large leaves, had mostly disappeared. The whole aspect was drier and less luxuriant: from the point of view of pasturage it was certainly less desirable.

This example was under favourable conditions. When these are less good the changes towards increased dryness are more pronounced and the time that elapses before regrowth is complete is extended. Very frequently fires occur before re-establishment and each fire has an increasingly deleterious effect, so that after very frequent fires the vegetation become sparse and largely made up of reeds, low bushes or bulbous plants which have no feeding value for animals and very little holding power on the soil and which produce very little soil improvement. The whole upper portions of many of our mountains are now in this condition though the general type of climate and moisture lead one to expect an especially vigorous vegetation. Fires followed by erosion by rain and wind have resulted in so great a removal of soil that only the most resistant plants which make little demand are able to survive.

People can and do say in this connection,—"Why bother about the mountains which are of no value as land; let us concentrate on the fertile low grounds." This is a very short-sighted view. The condition on the

mountains has a decided influence on the slopes and valleys at the base; an influence shown in more than one way. The most important is on the water supplies, especially on springs and streams. When the vegetation is undisturbed and the soil well penetrated by roots and containing organic matter, the rain water penetrates. In part it is held, in part it percolates down and escapes in springs and streams. The percolation is gradual and the soil protected from loss of evaporation and hence the streams continue to flow evenly. On the other hand, when the vegetation is destroyed by fire the rains either remove the unheld soil or compact it. In either case the water runs off at once and little or none is held. The streams come down in flood but continue flowing for a short time only. Floods are very liable to occur in the low lands and the rush of water from above in addition to the ordinary rainfall causes dongas or other forms of erosion. Also in the sparse vegetation following fire such water as is kept in the soil is liable to be lost by evaporation.

Destruction of the vegetation has another serious effect on water supplies. The mountains here are frequently covered by mists brought up by the South-East winds in summer. These clouds condense on the plants but only to a negligible extent on the soil itself or on rocks. The late Dr. Marloth demonstrated some years ago that the condensation by bushes and reeds might reach an amount corresponding to several inches of rain. In unburned vegetation this reaches the soil and helps to keep streams running. When the vegetation is burnt it is wholly lost. As the whole country is dependent on the mountains for its water supply it would seem obvious that a preservation of the vegetation on them is both urgent and essential.

BEES AND BEEKEEPING IN SOUTH INDIA*

Introduction.—Among insects, in fact, among the numerous lower animals, the honey bee occupies a unique position. It has been man's associate practically from prehistoric days. In view of the honey it yields and in consideration of the various virtues displayed by the creature in its social life this creature was not only held by the ancients in high esteem but was even endowed with divine powers and became the centre of many myths and superstitions. It was probably due to such ideas that the bee was added as an insignia by great men; it is said to appear on the crowns of the Egyptian kings, on the arms of the Pope and on the imperial robes of Napoleon! Honey and wax were attributed divine properties and in Christian rituals honey was given to babies in baptism and the Church candles were to be of pure wax! In India, the existence of bees and the usefulness of the products we get from them are facts well known to almost every layman. But very few among us possess any clear and definite ideas regarding the natural history of bees or about the aetiology and purpose of the useful products man gets from them. There is of course, reference in different Indian literary and medical works to honey as Madhu and to the honey bee as Madhu makshika (literally honey fly) the exact term by which it is known in the vernaculars, though it is scientifically incorrect to call it a fly. The little that is known of them may be more or less summed up in these statements (1) that bees abound in forests, (2) they give us some very valuable and useful products, (3) they are a proverbially hard-working and industrious lot, and (4) that they sting. All the rest regarding them has been practically a sealed book to most of us. The honey bee is, therefore, one of our familiar creatures and yet one about which we really know very little!!!

The primary object of this paper is to present in a very compact and popular form a very brief account of the honey bees we have in South India and the native methods now in vogue in the different tracts in artificial beekeeping and honey gathering, and secondly, to give a very short summary of the attempts now being made by the Entomological section at the Coimbatore Agricultural Research Institute to carry on investigations in this line with a view to demonstrate and popularise the modern methods of beekeeping as is practised in many of the Western Countries. One important excuse for publishing this paper with all its inevitable imperfections is the fact that we have absolutely no previous records of a connected form relating to bees in South India and that there is a demand from many people nowadays for a publication of this kind.

II. *General Facts Regarding Bees and Honey Bees.*—Before we enter into the main theme of beekeeping it will be advantageous to get some clear ideas regarding the position of the honey bees in the animal

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kingdom, their nearest relatives and some general facts regarding their natural history. Though popularly the term 'Bee' has been understood to refer to the domesticated honey bee, because of its long and intimate association with man, the name can be applied without mistake to a number of other insects; in fact, over four thousand different insects are known which come under this designation and all of them including the honey bee being classified as a group called *Apidae* (Bee family). The various bees, numerous wasps and differents kinds of ants constitute the three important sub-divisions of the well-known insect order *Hymenoptera.* Very familiar examples of bees other than the honey bee are the carpenter bees and the leaf cutting bees. A common example of the former is the stout bluish black insect (*Xylocopa*) found flying about houses and gardens with a strong buzzing noise and frequently seen boring into wood work (hence its name); the leaf cutter bees (*Megachile*) are generally smaller than the carpenter bees and these have the habit of cutting and removing away portions of leaves from rose and other garden plants. Most of the members of the bee family share some common features, the most important of them being the habit of visiting flowers to collect pollen and nectar (hence called *anthophila*), the possession of a long tongue which helps them in probing into flowers and the presence of plumose branched hairs on the body. In the matter of growth and development also they are similar—the pregnant female lays a number of single eggs; these hatch into helpless fleshy grubs which have to be fed by others until they pupate and from the pupa the adult bee emerges. Thus every bee passes through a complete metamorphosis during development as in beetles or butterflies. As against these similarities numerous differences are noted between different kinds of bees especially in their habits which enable us to classify them into such groups as underground nesting, surface nesting, tree nesting, parasitic, solitary and social bees. The honey bees come under the last group.

In India, we have over thirty genera included in the bee family (*Apidae*) including over two hundred known species of bees and the insects known as honey bees constitute but one of these genera (*Apis*) including three species. These three species which are the chief sources of honey in India and another minor insect the *Melipona* (Dammar or stingless bee) constitute the four genuine honey bees found all over the Indian region. All these bees are social insects and live in colonies. The three species of *Apis* and their fundamental features are (1) *Apis dorsata*, F., Rock Bee. This is the largest of the Indian honey bees and gathers plenty of honey; it builds long big open single combs which may often be four feet long on tall forest trees, along sides of precipitous cliffs and occasionally on the walls and other parts of buildings. The honey got from these hives in the forest forms the bulk of the material collected by hill people and sold in our bazaars. The irritable and ferocious temper of this bee and its confirmed nomadic habit of deserting its hives frequently have made it impossible to domesticate it: (2) *Apis florea*, F. This is the smallest of the three species and is known as the little bee. This also builds single combs which are, however, very small and often found hanging from bushes and corners of roofs, each comb usually gives but a few ounces of honey; (3) *Apis indica*, F. This is the common Indian honey bee, very commonly found both in the plains and the forests all over India. In size this is larger than *florea* and smaller than *dorsata*. This bee unlike the other two builds

several parallel combs generally in hollows of trees, caverns in rocks, on the walls inside wells and similar protected spots. This is the typical Indian honey bee and the only one which has so far been found to be capable of domestication. In the different hill tracts of South India the common bee found is a dark race of this *indica* The only other known species of *Apis*, besides these three Indian forms, is the European bee *A. mellifica*, L., which is the honey bee domesticated and extensively reared all over Europe and America and this species, except in a few minor features, is very closely similar to *indica* in structure, size and habits and hybridises freely. With regard to the affinities and phylogeny of these honey bees, though many entomologists like Linnaeus, Friese and Buttel-Reepen regard *mellifica* as the original species and the other three as its descendants, recent workers consider that the Indian form *indica* is the real ancestor. Professor Wheeler of Harvard, an eminent authority on social insects, in arguing out this point, adds the following very interesting and noteworthy remarks in favour of *indcia*. "Had a Hindoo entomologist preceded Linnaeus, *indcia* would be the type of the species, and the Hindoo, aware of the existence of two other species of *Apis* in his own and the neighbouring countries and nowhere else in the world, would properly regard the genus as of South Asiatic origin and the species *indica* as having spread to Europe and Africa and produced the dark race *mellifica*."

III. *The Members of a Bee Colony.*—As stated before the honey bees live in colonies. In an average thriving colony of the common Indian bee (*indica*) there is generally found a population of about forty to fifty thousand bees. This large number is, however, made up of three different kinds of individuals inhabiting the colony. These are the Workers, the Drones and the Queen—the workers making up the great bulk of the population (over 90 per cent.). The worker bee is an immature female smaller in size than the queen or the drone; on her devolve most of the important domestic duties of the colony such as gathering of honey and pollen, building of the combs, rearing the brood, defending the colony from enemies, attending on the queen and keeping the home sanitary and warm. To perform these duties satisfactorily the workers are also provided with the necessary structural adaptations. The tongue is comparatively long, the hind legs have basket-like hairy structures to collect pollen, the abdomen has glands to secrete wax which is the material used for house building, and they have a powerful sting for defence at the tail end of the body. The drone is the male bee and comparatively heavier built than the worker; its eyes are very large and meet at the middle of the head (this is the feature found in many male insects). It has no pollen basket, wax producing structures or a sting. The duty of the drone simply consists in acting as the husband of the virgin female bees. Very few drones are generally found in a healthy and vigorous colony, and at times there may be no drones in the colony at all. In every colony, usually any one healthy mother insect or queen is found. It is a mature female and is bigger and longer than the worker; she has no pollen baskets or wax plates but has a conspicuous combined sting and ovipositor, the latter to deposit eggs. The only function of the queen in a colony is to lay eggs and thereby add to the population of the colony and keep it strong. This egg laying machine is known to deposit two to three thousand eggs a day and under satisfactory conditions lives for two or three years.

It is thus found that in a bee colony there are three kinds of individuals or castes with different functions which contribute to the welfare of the colony, and each one of these is specially adapted structurally also to attend to its respective duties. The workers as their name implies, attend to all the material needs of the colony and the queen and drone play the parts of wife and husband keeping up the strength of the colony. The following passage regarding the bee colony is therefore, quite apt "The bee colony is a wonderful republic with many kings and only one queen, the citizens do all the governing without voting; the kings are powerless and the queen works as hard as and longer than any of her subjects." A few words as to the way in which the three bee castes arise in the colony may be added. Starting with a young queen who has just emerged from a pupal cell, we find her one fine afternoon emerging out on her virgin flight. She very usually meets a drone and they mate. This nuptial ceremony which generally takes place outside a hive is unfortunately attended by a tragedy; in the act of union the queen carries with her the generative organs of the husband and he is killed; (it may be added by the way that among many lower organisms the husband shares this unfortunate fate as a result of mating). The pregnant queen returns to her hive very soon and as a result of this union she carries the spermatic fluid received from the male retained in her spermathecal bag. In a day or two after her return from the wedding trip she starts laying eggs, practically her only function for the rest of her life; in each empty cell of the hive she lays one egg and she is found capable of laying three to four thousand eggs per day. One very striking peculiarity with the queen bee is that she is able to lay either fertilised eggs which will produce workers or non-fertilised eggs which produce only drones. This is due to the peculiarity in her generative mechanism which gives a control to allow or not allow an egg which passes out through the oviduct, to get impregnated by allowing a particle of the sperm from the sperm sac. This is a very remarkable capacity in the queen and fortunately or unfortunately it is absent in the higher animals and man! There is no difference, however, in the nature of the egg that will produce a worker or a queen and it is only food and other conditions which determine the production of either. Generally the queen lays fertilised eggs out of which the numerous workers which are essential to the needs of the colony emerge after a development period of 21 days. When a queen has to be raised and not otherwise, the workers build a few large cells and feed the baby grubs in them with special food, and from among these grubs an adult queen emerges in about 16 days; this special food "royal jelly" and the provision of larger cells to the chosen grubs appear to make these otherwise worker grubs fully developed queens! The drone egg takes about 24 days to develop into an adult bee. The difference in the period to attain maturity in the three different individuals is apparently due to the quality of food supplied to each. Various and marvellous are the numerous activities of these individuals, especially of the workers which go to regulate and to maintain the multifarious normal and abnormal needs and the domestic economy of a colony. It is hardly possible in this short paper to deal with the numerous facts and theories connected with the sex relations, the development of the sexes and other allied phenomena connected with the multiplication and maintenance of the normal strength of a colony.

IV. *The Domestic Life and Activities of the Honey Bee—Beehive.*—As stated at the beginning the common Indian honey bee in the natural haunts lives in what are called hives made of combs constructed by members of the colony in well protected places. Each hive is made up of a number of combs generally remaining parallel to each other. The combs which are made of wax, are divided up into thousands of hexagonal cells, each comb having a double set of them one on each surface; and these cells serve as receptacles for the storage of honey and pollen and as chambers for the developing brood. The beehive with its remarkable architectural and economic arrangement, is one of the wonders of the insect world. In the words of the great poet Maeterlinck "No living creature, not even man, has achieved in the centre of his sphere what the bee has achieved in her own; and were someone from another world to descend and ask of the earth the most perfect creation of the logic of life, we should needs have to offer the hunble comb of honey." The mathematical accuracy with which the cells are arranged and the way in which the whole hive is constructed are features always evoking wonder and admiration. Adult bees of all the three different kinds when at home simply remain clustering to and moving along the surface of the combs and do not have any special lodgings. Usually the cells in the upper part of the combs are made use of for the storage of the honey and the lower ones are utilised for brood rearing. While the worker cells when closed are capped flat, those of the drone and the queen have different shapes; the drone cells which are usually found along the edges have a convex capping and the queen cells stand out from the margin as elongated conical projection. Wax which is the material with which these combs are built is a secretion which exudes as a semi-fluid substance, through some of the ventral plates of the abdomen of the workers and which solidifies into the plastic wax so ideal a material for constructing the comb. The best stone mason or brick-layer will simply marvel at the way in which the bee removes the wax from its belly, kneads it with the help of its mouth parts and uses it for comb building. During the busy season when cells have to be built at a rapid rate workers gorge themselves with honey and this stimulates wax production. It is said that to get a pound of wax, bees have to consume about 10 to 15 lbs of honey; as such, comb building and brood rearing go on vigorously when there is plenty of honey available.

Food of the Bee.—The food of bees, as stated before consists usually of nectar and pollen, from flowers. The adult bees chiefly feed on honey while the young ones have to be fed mainly on pollen, although it is often mixed with honey and water forming a paste called 'bee bread'. The developing grub in each of the brood cells is unable to find its food and has, therefore, to be fed with these materials by the nursing workers of the colony until they are full grown and about to pupate. Since the food of bees in all stages consists of materials from flowers of different kinds they generally thrive well in jungles, flower gardens and orchards where flowers of various kinds form their pasturage for both nectar and pollen. Occasionally, however, bees have been noted lapping up the honey dew of some plant bugs and it is said that they seek sugar in other places than flowers.

Honey.—Speaking of honey it may help us to have some clear ideas as to what it really is. The honey that we get from beehives is not the actual nectar which the insects collect from various flowers. This nectar collected by them from all sorts of flowers is swallowed by the creature and afterwards regurgitated into the honey cell. In the honey stomach of the bee in which the nectar remains before regurgitation, certain chemical changes take place and it is this changed stuff which is called honey. The bees knowing very well that pasturage may not be available during all the seasons in the year due to climatic variations, collect very briskly when there is plenty of pasturage and store quantities of honey which will serve them and the brood during the rainy or very chilly months when no pasturage is sufficiently available; during these months their outside activities are also very much curtailed. On the other hand during the spring and summer months when there is plenty of pasturage available the workers are found very industrious and busy, not only gathering stores of provisions but also actively engaged in comb building and brood rearing, the queen is also very active during this season of plenty and adds to the population of the hive by laying numerous eggs day after day. In view of the fact that the length of life of the worker bee is not more than three or four weeks and that many of them are liable to be killed in various ways, a proportionate increase in brood is thus quite necessary to keep up the normal strength of the colony. However, when due to very favourable conditions, the population of a colony increases enormously and there is a general feeling that there is not sufficient room or convenience for all the inmates, preparations for a family partition become evident. The reigning queen and a good number of workers from the hive fly out of the colony and start a fresh one in a new spot. This family partition is called *Swarming* and is often much more peaceful and harmonious in striking contrast to what often happens in human families. This appears to be a natural instinct on the part of all the members of the colony in helping the dispersal and distribution of the species. This habit is occasionally persistent in the bee; and has to be watched and proper precautions taken by the apiarist. There are numerous other points in the behaviour of bees which are the problems that will repay investigation.

Enemies of Bees.—Before we conclude this brief account of the remarkable family arrangement of the honey bee a few words may be added regarding some of the factors that often interrupt the machine like working and organisation of these remarkable insects. There are some enemies in the shape of diseases and pests. The Indian bee, unlike the European *mellifica* is so far free from the two notorious bee diseases—'the Isle of White disease' and 'foul brood'. In the shape of active enemies we have the bee eater among birds; but it is among insects we come across some of the dreadful enemies of the bees. A few years ago, the senior author discovered in the Bababuddin hills in Mysore a wasp which behaves as a typical bee hunter—attacking and carrying away bees. ‡Some of the common hornets also occasionally attack bees. The common hawk moth* attacks the hives and feeds on the stored honey. An inveterate pest of the hive is the wax caterpillar† which often devours the wax combs

‡ Recently described as a new species—*Philanthus ramakrishnae*, T. * *Acherontia styx.* † *Galleria melonella.*

and causes very serious damage especially in weak colonies. The other enemies of bees are miscellaneous animals of different kinds which rob them of their provisions; under this category, of course, comes man. The workers that defend the colony from such robbers and trespassers have, of course, their defensive organ in the sharp and poison inoculating sting. The writers believe that, but for the possession of a such protective weapon, man and other animals would have by now made the honey bee a creature of the past like the Dodo or the Mammoth!

V. *Bees and Man.*—We have so far gathered some information regarding the natural history of bees. Let us now come to the relations between bees and man. Man's association with the honey bees dates from time immemorial and the primary object of this relation has evidently been to take advantage of their labours and appropriate the honey from the bee colony for his use. We will just survey briefly how these products have been and are still being gathered by man in different parts of India and in what way these could be considerably improved with advantage. Since bees are more abundant in the jungles it is the people in the forest tracts that are more familiar with their activities and conversant with the methods adopted to procure these products. In spite of the fact that these honey mongers of the hills are very familiar with bees and their products, they have absolutely no knowledge of the elementary facts in the natural history of bees. All they know is that there are certain seasons when bee colonies increase in numbers and when beehives get filled with honey which they have to appropriate promptly. The methods adopted to get honey are crude, wasteful and barbarous and these apply to gathering of honey from both the rock bee (*dorsata*) and the common bee (*indica*). During night when the bees are inactive and generally remain clustered on the surface of the hive, burning torches are applied to the hive and in this process most of the bees are killed and may of them badly suffocated; in order to save himself from possible stings during the operation, the man covers his body with a thick sheeting and closes his face with a veil or smears it with ashes to make the sting ineffective. When the bees are thus killed or disabled, the combs are removed and the process of honey gathering starts. This consists in cutting the combs into pieces and then pressing and squeezing every bit of them with the hands and securing the juice thus obtained as honey. Any one with a smattering of insect lore can easily form some idea as to what the components of this liquid are and the degree of its purity. In addition to honey it contains, among other things, the body juices of the developing grubs in the brood cells, lumps of pollen and pieces of wax from the crushed combs. This stuff constitutes the great bulk of what we get from our bazaar grocers as pure honey, though there are worse substitutes often sold as honey. Gradually as half civilised man realised the value and good properties of honey, it occurred to some that, instead of searching and locating bees for honey in the different parts of the hills, the bees may be attracted into some trap chambers and made to build their combs and store honey in them. With this idea the crude pot hives, log hives, straw hives (skeps), beer casks and other improvised contrivances came into vogue to breed the bees and this was the beginning of what may be called beekeeping by man; but the methods of gathering the honey continued in the same old crude ways, sacrificing the bees and their combs. It was not until the middle of the last century that some beekeepers in the West realised the

cruelty, the economic loss and the impurity caused by the inhuman methods of obtaining honey from the combs. Robbing the honey bee of their stores of honey, which is never intended for man's use, is never a commendable act, but by getting the stuff without smoking and crushing the bees is certainly more humane and the better evil of the two. As a result of the gradual realisation that the existing methods of honey gathering were more or less like killing the goose that lays the golden eggs, hives with movable frames were devised by the use of which the beekeeper could gather honey in a pure state and without sacrificing the bees. The introduction of the hive with movable frames is chiefly associated with the name of a clergyman Langstroth the inventor of the well-known standard hive known after him; and if only the bees could talk, they would with one voice express to him their external vocal gratitude for rescuing them from practical extinction. Since the introduction of different kinds of hives with movable frames the crude methods of honey gathering have almost disappeared in the Western countries. In South India, on the other hand, wherever anything like beekeeping has been existing, the primitive methods still prevail as in the hill districts of Coorg, Mysore and Wynad. Hollow logs or earthen pots smeared with wax are used as artificial hives and when these are colonised by the bees and sufficient honey becomes stored the bees are smoked out and the honey squeezed out in the same old way. Interesting accounts of such methods that have been in vogue in the different hill districts of India and samples of colossal ignorance displayed by revenue and forest officers regarding the natural history of bees could be found in a Government of India publication on the subject. Within the past two or three decades, however, attempts have been made here and there to rear Indian bees on modern scientific lines. The Jesuit fathers of Trichinopoly have done some very valuable pioneering work with *indica* and Father Newton's paper on this work contains some valuable information. The bulletin and another paper on beekeeping by Ghosh though mainly compilations from works dealing on the Eoropean bee *mellifica* also deal with the *indica* bee adding to our knowledge of this local species; the author does not, however, seem to encourage the keeping of the indigenous bees! A few enthusiasts here and there in recent years have tried importing colonies of the European bee *mellifica*, but the success so far attained by such attempts do not appear to be very encouarging. While on this subject of trials with the European bee, two or three important points have to be noted. In the first place it is not an easy task to transfer a species acclimatised to a temperate region to the plains of tropical India; of course, trials may be made on the hills. Secondly, the European bee is subject to two or three destructive bee diseases called 'foul brood' while our *indica* has been found susceptible to any such maladies. From this aspect it is not at all advisable to import the exotic bee and stand the chance of infection being carried to India. In the third place the cost of transferring a colony from a European country is prohibitive and can never be within the reach of the ordinary farmer. Who can say that the exotic bees, with all their original superiority, will not deteriorate like European univolting silkworm, when introduced into the warm tropics; that they will is the opinion of Maeterlinck. In this connection it will not be inappropriate if I had the following unanimous resolution passed at an All-India Entomologists' meeting at Pusa in 1919 on this subject—"This meeting considers that there is considerable danger of the

introduction into India of bee diseases by the unrestricted importation of bees, beeswax and honey from countries infected with such diseases and that such importation should therefore only be permitted under necessary restrictions". In the opinion of the writers, therefore, the best thing to do is to try the local indigenous bee *indica* and effect all possible improvements by research and experiments in various directions. This is quite in consonance with the views experienced by two apiarists who have each had a long experience of over two decades with *indica*, viz., Father Newton of Trichinopoly and Lieut. Cousins of the Punjab. The following remarks of the former are worth quoting:

"It would be regrettable if people in the plains of India where *Apis mellifica* does not thrive were to be for ever deprived of such a fascinating pursuit as beekeeping from a mistaken notion that the Indian bee is not worth cultivating. I firmly believe that, given a good locality where honey yielding trees and crops are to be found in sufficient quantity, with proper hives and modern methods, the Indian bee in spite of its small size might prove sufficiently productive to justify its cultivation." As early as 1926, the junior author, out of curiosity, was having a few hives of *indica* under observation for some time and had opportunities to gather some practical knowledge of the art and this little start has stood him in good stead since 1931 when agricultural work was started by the Entomologist, and he was put in charge of the work. Besides the work at Coimbatore, trials with the Indian bee are going on in different parts of South India, and the Y.M.C.A. authorities have encouraged this industry as a part of their rural reconstruction scheme and actual rearing work has been going on in their important centre, Ramanathapuram, near Coimbatore since the year 1926. Such trials are also carried out at present in the Mysore and Travancore States not to speak of many private educated parties who have taken to this hobby in different places in South India.

VI. *Work at the Coimbatore Farm.*—The more important ideas with which work on rearing the Indian bee (*indica*) was started at the Coimbatore College were, in the first place, to definitely ascertain by experiments and research in various ways as to whether the common bee of the Indian plains (*A. indica*) can be successfully domesticated, secondly to work out all possible means which would improve the quality of the bees and the yield of honey, thirdly to work out thoroughly the economic side of beekeeping and finally to recommend keeping of this bee and give the necessary instructions and advice to those who are interested in the industry and who intend starting beekeeping either as a hobby or as a cottage industry. With these basic objects, work was started in 1931 with 12 colonies hived from local wild swarms. In 1932 the hives increased in number to about 35 and now we have 25 hives in flourishing condition excluding a good many sold out. It is generally found that the general health and prosperity of the bees depend on a good many factors, the most important of which are (1) availability in the vicinity of sufficient pasturage for gathering honey and pollen, (2) the climatic conditions prevailing and (3) absence of enemies like the wax moth. We have hardly any previous records on these points with regard to South Indian conditions,

Pasturage.—On the Coimbatore farm we found that, during the South-West monsoon months July to October, the pasturage becomes rather scanty and the activities of the bees become considerably minimised; on the other hand from January to June plenty of pasture becomes available and this period may be considered the 'honey season' in this area. Among pollen yielders in this locality, cholam and maize are found the best; next in the order of their value come cumbu, castor, garden Zinnia, Peltophorum and others. Regarding the nectar bearing plants, Cambodia cotton and tamarind have been found to be the best in the locality; the former appears to be a very good honey yielder and on a rough estimate an acre of this crop is found capable of giving nectar production of ten pounds honey during a season. Tamarind also appears to be almost as good as cotton. Further investigations are made in this line with regard to the suitability of other trees like nim, citrus, plantains and field crops like lucerne, coriander etc. Bees are found to use considerable degrees of discrimination in the selection of pasture and it appears that there are many factors which guide them besides smell, colour, shape etc., of flowers. *Strobilanthus* flowers are considered to be the best honey yielder in the sholas of the Nilgiris and it is intended to try these in due course. Investigations are being made and some data have also been collected as to the time of the day when the bees visit the different flowers and their preferences.

Honey.—As regards the quality of the honey gathered from the different main sources, cotton, tamarind and nim, each has its special taste, colour, aroma and degree of sweetness, and the apiarist after some experience is able to easily detect the special quality by its appearance and aroma. Nim honey, though not available in large quantities, is regarded to possess high medicinal properties. As to the yields of honey, our experience has shown that during an average year of normal seasonal conditions favouring good pasturage, and with sufficient care, one can get from a healthy hive from 10 to 12 pounds of good honey. It is not the honey value alone of these hives that one has to consider. Such a healthy hive gives out swarms periodically and if these latter are properly hived, these also begin to yield their quota in a few months. Thus a good deal of the success depends upon the practical skill of the apiarist in taking advantage of the proper opportunities in various ways. Some of the various items that are now engaging our attention in the matter of honey production are—studies on comparative food value of the different kinds of honey by analysis, fermenting and ripening of honey, the proper season for honey gathering, temporarily moving bees to better pasturage, swarming and various phenomena connected with them, artificial queen rearing, artificial partition of colonies, different methods of hiving wild colonies and various incidental details in connection with bees.

Appliances.—A few brief remarks may be added regarding the appliances we use in the work. The hives used by us are of the pattern advocated by Father Newton with one brood chamber and one or two supers, and we have been able to get it made locally at Rs. 4/- each and there

has been a very good demand for these hives during the past two years. Regarding the honey extractor also it may be added that after some trials we have been able to devise a fairly cheap and efficient honey extractor costing about Rs. 6/-. Trials are also proceeding in the matter of reducing the cost of all such outfit so that we may bring it to the lowest possible minimum for suggestion to poor ryots. The proper use of these appliances and the careful handling of the bees in the combs will considerably add to the health and safety of the bees? Our work in Coimbatore has now spread into the districts and some of our men are carrying on trials in this work under our guidance in the mofussil research stations at Anakapalle, Samalkota, Taliparamba and Coonoor, and it is hoped that in course of time this industry will become very popular in South India.

VII. *Economics of Beekeeping.*—Before concluding, some definite data may be added on the economics of beekeeping as far as our experience has shown. During one year, from eleven healthy hives we got 118 lb. of honey which at Rs. 1/4/- per lb. comes to Rs. 148/-. As stated before, each of these hives gave out a swarm which, in turn yielded about Rs. 77/- worth of honey. Thus in a year out of eleven hives we were able to get Rs. 225/-. These 22 hives at Rs. 4/8/- each and the honey extractor costing Rs. 6/- come to Rs. 105/-. The initial cost of hiving the original eleven wild colonies comes to Rs. 22/-. Thus the outlay comes to Rs. 127/-. The interest on this outlay at 7½ per cent. comes to Rs. 9/12/-; the hives and the extractor are expected to be useful for at least 15 years and as such the depreciation on these will be about Rs. 7/-. The labour charges which are practically nothing, since the keeper is expected to attend to the work, may however be put down to Rs. 10/- for the year. The total annual expenditure therefore, comes to Rs. 30/- roughly and deducting this amount from the outturn the profit realised comes to Rs. 195/-, thus making an average net profit of nearly Rs. 20/- on each hive.

A farmer with some initial training and experience and particularly with the aptitude and enthusiasm really necessary for this kind of work, can easily manage about 20 hives provided pasturage and other conditions are satisfactory. But, for an amateur it is advisable to start with a few hives which would effect considerable saving in the initial outlay and from the experience and profits gained from these, he can expand his work. Further trials are being made in these various directions.

Other aspects of great importance in connection with the honey bees are their different relations to numerous plants and their economic importance in orchards, etc., as pollinators of different kinds of flowers. Observations and investigations in this direction on these habits of the bee have not been sufficiently made in India and as such would offer unexplored fields for study.

VIII.—*Conclusion.*—In concluding this necessarily brief account of this interesting subject we may add that, with some propaganda and advertisement, the demand for pure honey, as an article of daily consumption, is bound to increase. The Indian, with his proverbially spiritual

mentality, and aversion to taking life, will surely appreciate the modern methods of honey gathering and as he gets sufficient and correct information regarding the natural history of the bees, beekeeping on modern scientific lines in South India is sure to have a bright future. But it must be mentioned here that keeping bees is certainly not a short cut to fortune, but as a cottage industry, coupled with other items such as poultry keeping, silkworm rearing, etc., it would go a long way to supplement the ryot's scanty income from agriculture.

Apart from the material benefits we can secure by keeping bees it is needless to add how educative and inspiring the life activities of the bees are in various ways. Their sense of duty and co-operation for the common good, their unceasing diligence and industry, their wonderful architectural and sanitary instincts and their marvellous sense of domestic economy and forethought, bordering on intelligence, are some of the many features which have, from time to time, been pointed out by poets and philosophers as worthy of imitation by many an erring and wayward man.

MEETINGS, CONFERENCES, ETC.

IMPERIAL INSTITUTE

REPORT ON LIME OILS FROM CEYLON

THE samples which are the subject of this report were forwarded to the Imperial Institute by the Director of Agriculture. They were stated to represent hand-pressed and distilled lime oils prepared by the Agricultural Chemist, and it was desired to ascertain their quality and commercial value.

DESCRIPTION

The oils weighed 4 oz. each, and were as follows:

(1) *Distilled Oil.*—This oil as received was very slightly opalescent owing to the presence of moisture. After filtration through paper it was clear and almost colourless, but showed a slight greenish tint.

(2) *Hand-pressed Oil.*—This sample as received contained about 0·8 per cent. of a solid white deposit apparently consisting of citraptene. After filtration the oil was clear, and of rather dark green colour.

RESULTS OF EXAMINATION

The oils were found to have the following constants, which are shown in comparison with the range of corresponding figures for distilled and hand-pressed West Indian lime oils:—

	Present Samples		West Indian Lime Oil	
	Distilled	Hand-pressed	Distilled	Hand-pressed
Specific Gravity at 15·5/15·5°C	0·8647	0·8942	0·859 to 0·872	0·878 to 0·884
Optical Rotation qD	+40·0° at 19°C	+34·02° at 18°C	+33° to +48°	+30° to +38°
Refractive Index nD 20°C	1·4770	1·4897	1·470 to 1·475	1·4820 to 1·4860
Aldehydes (expressed as citral) per cent.	5·6*	9·4*	1 to 2	6 to 9
Non-volatile matter per cent.	3·3	13·0	—	10 to 18
Solubility in 90 per cent. alcohol at 15·5°C	Soluble in 4·8 vols. with very slight turbidity.	Soluble in 4·5 vols. with slight turbidity.	—	Soluble in 4 to 10 vols. with slight turbidity.

* By the hydroxylamine method (*Analyst*, 1930, *55*, 107).

COMMERCIAL VALUE

The oils were submitted to brokers in London, who regarded both products as of good commercial quality and of about the same value as the corresponding types of West Indian lime oils, which were then quoted as follows:

			Per lb.
Distilled oil	...	...	30s
Hand-pressed oil	...	...	45s

REMARKS

The results of examination show that the distilled lime oil contained an unusually large amount of citral, and more resembled in this respect an expressed lime oil. This factor may account for the high refractive index. The oil possessed a very satisfactory odour.

The expressed oil, in comparison with commercial samples of hand-pressed West Indian lime oils, possessed an exceptionally high specific gravity, and its refractive index was higher than that usually observed. The amount of non-volatile matter present was however, not excessive. The sample possessed an agreeable odour, which however was not quite so strong as that of some of the commercial samples with which the oil was compared, notwithstanding the fact that the oil contained a high percentage of aldehydes.

REPORT ON GERANIUM OILS FROM CEYLON

THE samples which are the subject of this report were forwarded to the Imperial Institute by the Director of Agriculture.

The samples were stated to represent geranium oils (*Pelargonium graveolens*) prepared by the Agricultural Chemist, and it was desired to ascertain their quality and commercial value.

DESCRIPTION

The samples weighed 4 oz. each, and were as follows:

(1) *Green Stage.*—This oil as received was turbid owing to the presence of moisture, but after filtration through paper it was clear and of a pale greenish-brown colour.

(2) *Flowering Stage.*—This was a clear, pale green oil.

RESULTS OF EXAMINATION

The oils were found to have the following constants, which are shown in comparison with the ranges of corresponding figures for commercial Algerian and Bourbon geranium oils:

	Present Samples		Commercial geranium oils	
	Green Stage	Flowering Stage	Algerian	Bourbon
Specific Gravity at 15·5/15·5°C	0·9063	0·8992	0·892 to 0·904	0·888 to 0·896
Optical Rotation qD	−11·66 at 17°C	−13·03° at 18°C	−6·5° to −12°	−7·7° to −13·8°
Refractive Index nD20°C	1·4608	1·4610	1·464 to 1·472	1·461 to 1·468
Acid Value	94·6	82·0	1·5 to 9·5	1·5 to 12
Ester Value	25·3	18·1	31 to 70	50 to 78
equivalent to esters (expressed as geranyl tiglate), per cent.	10·7	7·6	13 to 29·5	21 to 33
Ester Value after acetylation	197·3	210·0	203 to 234	206 to 233
equivalent to "total alcohols" (expressed as geraniol), per cent.	63·7	68·5	66 to 78	67 to 77·6
Solubility in 70 per cent. alcohol at 15·5°C	On adding about 2·5 vols. an appreciable amount of solid separated from the clear solution and did not dissolve on the addition of 10 vols.	Soluble in 1·9 vols. with slight turbidity; a little solid matter separated on diluting to 10 vols. or more.	Soluble in 2 to 3 vols.	Soluble in 2 to 3 vols.
Solubility in 90 per cent. alcohol at 15·5°C	Soluble in 0·7 vols. becoming turbid on further dilution	Soluble in all proportions. Slight turbidity with more than 1 vol.	—	—

There are no very marked differences between the constants of the two samples, but it will be seen that, in comparison with the figures recorded for commercial geranium oils, both samples had low ester values and high acid values, and that the oil from the green plants contained a low percentage of "total alcohols". It would appear that some of the esters originally present in the oils had suffered hydrolysis. Further, the oils apparently contained a certain amount of stearoptene (solid hydrocarbons) which adversely affected their solubility.

As regards odour, there was no very notable difference between the two oils; the oil from the flowering plants, which contained the higher percentage of alcohols, calculated as geraniol, had however a rather more pleasant odour than that from the green plants. Compared with commercial Algerian and Bourbon geranium oils the odour of both samples, although very pleasant, was not very intense, the odour of the commercial oils being stronger, more roselike and less volatile.

COMMERCIAL VALUE

The samples were submitted to (a) and (b) essential oil distillers, and (c) a perfumery expert.

(a) The first firm of distillers furnished the following observations:

"These two samples have been examined with interest and we have to report that we find the odour of both very good. If bulk deliveries could be maintained we think the oil should find a ready market in this country. The analytical figures differ widely from normal Bourbon geranium oil; of the two, that produced from the "flowering stage" is, in our opinion, the better.

"There is always initial difficulty in putting a new oil on the market, and buyers have to be tempted with a low price in order to persuade them to make the trial. The price of Bourbon geranium oil today is about 20s per lb., and we should value the present oils from Ceylon at about 17s to 18s per lb."

Since the date of the above report the price of the Bourbon oil had advanced to about 23s per lb.

(b) The second firm of distillers regarded the oils less favourably and reported as follows:

"We confirm the characters observed in your Laboratory. The oils possess however a very low odour value without the sweetness and strength of Algerian and Bourbon Geranium oils. This may be due some extent to the low ester content. The oils would not replace the usual Geranium oils on the market. With regard to value we do not think it would be worth any more than 10s per lb.".

(c) The perfumery expert, who has had much experience of geranium oils, expressed the following opinion, which agrees generally with that of the first firm of distillers:

"I have now had an opportunity of examining the samples of geranium oil from Ceylon and am of opinion that whilst they would not be classed as first grade oils they would certainly be marketable at a price little below that at which average oil is being sold.

"The oils are distinctly different in type, that from the flowering plants being the sweeter whilst the other is more persistent. Neither of these characteristics however is so marked as to make either of the oils of greater market value than the other, and the yield of oil should determine the best condition of the plants for cutting. As you say, however, the analytical figures of the oils are in certain respects abnormal and the experimental distillations should be repeated before definite conclusions are drawn."

REMARKS

The constants of these geranium oils are unusual in certain respects, especially the high acid and low ester values. The odour of the oils is undoubtedly somewhat inferior to that of the Bourbon and Algerian oils of commerce, but it is difficult to account for the wide difference of opinion expressed by the two firms of distillers.

In any case it would be advisable to adopt the suggestion of the perfumery expert that further experimental distillation should be made and samples submitted for examination and report.

REPORT ON ALEURITES MONTANA OIL

IN February 1932 a sample of *Aleurites montana* fruits, stated to have been obtained from China, was submitted to the Imperial Institute by the Director of Agriculture in Ceylon, and a report on the composition of the fruits and the characters of the oil was furnished by the Imperial Institute on the 24th August 1932.

The Director of Agriculture had requested that varnish-making trials might be made with the oil in comparison with that of *A. Fordii*, and these have been carried out by Dr. L. A. Jordan, Director of the Research Association of British Paint, Colour and Varnish Manufacturers and a member of the Imperial Institute Sub-Committee on Tung Oil. Dr. Jordan has now furnished the following report.

REPORT UPON THE QUALITY OF VARNISH PREPARED FROM THE OIL OF CHINESE ALEURITES MONTANA FRUITS FROM CEYLON

The test was carried out in fulfilment of a request from the Director Agriculture in Ceylon in whose region *Aleurites montana* flourishes better than the *Fordii* species. The two oils are of the same general character, but that of *A. montana* possesses constants indicative of a lower quality of material. These experiments were made upon oil expressed cold in the laboratory from seed obtained from China by the Director of Agriculture, Ceylon, and the characteristics of the oil so obtained have formed the subject of a previous report (August 1932).

The results of the present tests must be interpreted with due reserve, since though a varnish was made from each of the oils by a comparable procedure the very nature of the process of manufacture introduces inconsistencies from which it is impossible to conduct an exact repetition. The only sure guide would be the experience of some hundreds of preparations.

The materials used were:

(a) the *montana* oil already referred to

(b) the *Fordii* oil for comparison was an American high grade oil comparable with those obtained by pressing samples of *A. Fordii* in the laboratory.

(c) a standard commercial Pb-Co drier was added in proportions usual in varnish practice.

(d) pure white spirit was employed for thinning.

The varnishes for test were made up in a stainless steel pot heated by gas, and the procedure resembled as nearly as possible that employed upon large scale work. The oil was heated to 240°C in 35 minutes and high grade W.W. rosin equal to 50 per cent. by weight of the oil was stirred in. The temperature was then held at 240°C for 90 minutes, and after cooling to 140° the varnish was thinned with white spirit and the driers added. The *Fordii* varnish bodied to a notably greater extent under this treatment, and required more thinner to yield a product of the same viscosity as that from *montana* oil.

Owing to the greater proportion of volatile thinner in the *Fordii* varnish, the films submitted to weathering tests would be of slightly less thickness than those of the *montana* varnish.

Both the resultant varnishes were pale and clear, brushed satisfactorily and dried in a normal manner.

Panels were prepared for test in the open and by artificial weathering. For the open air test, monel metal panels were brushed and exposed for nine months at 45° to the horizon facing south. For artificial weathering, panels were prepared on

(a) mild steel primed with a lead chrome paint

(b) monel metal

(c) Parkerised mild steel

(d) Bonderised mild steel.

They were submitted to a standard cycle of treatment made up as follows:

Monday-Saturday.

2 hrs.	in refrigerator at 21°F.
21 ,,	exposed to two electric arcs in vita glass; sprayed with water for 2 mins. every 20 mins., and the air in the tank at approx. 110°F and 50 per cent. relative humidity.
1 ,,	inspection and change of carbon.
24 hrs.	

Sundays.

23 hrs.	exposed to arcs.
1 ,,	changing of carbons.
24 hrs.	

The artificial weathering was carried on to 3005 hours.

Results.—The natural weathering, during the period of nine months from September 1932, showed little difference between the two varnishes. The only breakdown consisted of elongated cracks through which the bare metal was distinguishable. The *montana* varnish showed rather fewer cracks per unit area of the panel, but these cracks were perceptibly wider than those on the panel coated with *Fordii* varnish.

In the case of artificial weathering, cracking was again the only failure, and the following table gives the hours of exposure leading to breakdown in each case.:

	Chromed mild steel	Monel metal	Parkerised mild steel	Bonderised mild steel
Montana	*2032* h	*1828* h	1413 h	*1650* h
Fordii	2010 h	1690 h	*1482* h	1413 h

The better figure is italicised in each case. It will be seen that there is a slight bias in favour of the *montana* varnish on durability grounds, but this is offset by the less thinning it received in preparation; the differences observed throughout are within the limits of variation which might be observed in two varnishes made from the same materials.

RUBBER RESEARCH SCHEME (CEYLON)

Minutes of the twentieth meeting of the Board of Management, held at 11 a.m. on Thursday, March 15, 1934, in Room No. 213, New Secretariat, Colombo.

Present:—Dr. W. Youngman (in the chair), Messrs. C. H. Collins, C.C.S., (Representing the Financial Secretary), I. L. Cameron, A. E. de Silva, C. E. A. Dias, J.P., H. R. Freeman, M.S.C., F. H. Griffith, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. J. L. Kotalawala, M.S.C., P. R. May, F. A. Obeyesekere, M.S.C., C. A. Pereira, B. M. Selwyn, E. C. Villiers, M.S.C., Col. T. Y. Wright.

Mr. T. E. H. O'Brien, Director of Research, was present by invitation and acted as Secretary.

Apology for absence was received from Mr. L. P. Gapp and Mr. B. F. de Silva.

MINUTES OF THE NINETEENTH MEETING OF THE BOARD

Draft minutes which had been circulated to members were confirmed and signed by the Chairman.

BOARD

The Chairman welcomed to the Board Mr. C. H. Collins who had been appointed to represent the Financial Secretary in place of Mr. C. W. Bickmore, who was shortly leaving the island on retirement. He took the opportunity of expressing his personal indebtedness to Mr. Bickmore for his valuable assistance since the inception of the Board and thought that members would also wish to express their appreciation of his services. It was decided to record a vote of thanks to Mr. Bickmore for his services to the Board.

The Chairman also welcomed to the Board Mr. P. R. May who had been appointed to act from March 1st in place of Mr. E. W. Whitelaw who was shortly proceeding on leave. Mr. I. L. Cameron was also proceeding on leave but an acting appointment had not yet been made.

DECISIONS BY CIRCULATION OF PAPERS

Appointment of Assistant Chemist.—The Chairman reported that Mr. M. W. Philpott had accepted appointment on the revised terms which Board members had approved by circulation of papers. It was expected that Mr. Philpott would arrive in Ceylon during April. Correspondence relating to the appointment was tabled.

ACCOUNTS

(a) *Expenditure in excess of estimates during 1933.*—The Chairman reported that covering sanction was required for over-expenditure of certain individual votes during 1933. Total expenditure for the year was substantially below the estimate. The votes were approved.

(b) *Balance Sheet and Income and Expenditure Account for 1933.*—The Chairman invited comments on the Auditor's report and accounts which had been circulated to members. After discussion, the accounts and Auditor-General's report were adopted.

(c) Fixed deposits made since last meeting were reported.

(d) Accounts of Nivitigalakelle and Dartonfield Estate for November and December, 1933 and January 1934 were tabled. It was reported that copies of the accounts were being circulated to the Estate Committee as from January, 1934.

(e) Statements of receipts and payments of the Board and of the London Advisory Committee for Rubber Research (Ceylon and Malaya) for the quarter ended December 31, 1933 were adopted without discussion.

ANNUAL REPORT FOR 1933

The Chairman invited comments on the report of the work of the Rubber Research Board in 1933, which had been circulated to members. After discussion and minor alterations of wording, the report was adopted. It was decided that the report should be published in the same way as last year.

DEVELOPMENT OF THE RESEARCH SCHEME

(a) Recommendations of the Estate Committee in regard to Buildings at Dartonfield.

1. FACTORY

After discussion it was decided to accept the specification and tender submitted by Messrs. Brown & Co., Ltd. for the construction and equipment of an experimental factory at Dartonfield Estate, subject to consideration by the Committee of various suggestions made during the discussion. A vote of Rs. 60,000 was approved to cover the cost of factory together with a further Rs. 25,000 for the purchase of vulcanizing and testing appliances.

2. OTHER BUILDINGS

It was decided to invite Messrs. Billimoria and De Silva to prepare plans of other buildings sanctioned in the estimates, for consideration by the Board at the next meeting. Consideration of the cost of the buildings was deferred until plans and estimates were available.

(b) Other recommendations of the Estate Committee.

1. CART ROAD

The vote for extension of cart road was increased from Rs. 3,000 to Rs. 4,000.

2. ESTATE SUPERINTENDENT

The Chairman reported the appointment of Mr. D. L. Nicol as Estate Superintendent as from January 15th, 1934. Approval was given for a bungalow to be rented at Pimbura Estate and a motor cycle allowance to be paid to Mr. Nicol until quarters are available at Dartonfield.

3. BULLOCK CART

A vote of Rs. 250 for the purchase of a pneumatic tyred bullock cart was approved.

4. RUBBER RESTRICTION

In the event of a rubber restriction scheme being introduced, the Chairman was authorized to apply to Government for Dartonfield to be exempted from restriction of crop.

5. MEMBERSHIP OF PLANTERS' ASSOCIATION, ETC.

After discussion it was decided to retain membership of the Planters' Association and the Ceylon Estates Proprietary Association in respect of Dartonfield Estate and to apply for membership of the Low-Country Products Association.

Consideration of other items on the agenda was postponed until next meeting.

PUBLICATIONS

Fourth Quarterly Circular for 1933 was tabled.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 MARCH, 1934

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	29	6	29	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	5	1	...	...	...	5
	Piroplasmosis	...	...	...	...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	3	3	1	...	2	...
	Anthrax	2	2	...	2	...	...
	Rabies (Dogs)	2	...	...	...	...	2
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	11	11	...	...	11	...
	Anthrax (Sheep & Goats)	37	21	...	37	...	...
Central	Rinderpest	FREE					
	Foot-and-mouth disease						
	Anthrax						
	Bovine Tuberculosis						
	Rabies (Dogs)						
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	121	15	121	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Northern	Rinderpest	90	10	14	68	...	8
	Foot-and-mouth disease	...	..	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	22	...	22	...	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	FREE					
	Foot-and-mouth disease						
	Anthrax						
	Pleuro-Pneumonia (Goats)						
	Rabies (Dogs)						
North-Central	Rinderpest	12	12	3	9	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	132	132	39	1	92	...
	Anthrax	...	...	...	..	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Sabaragamuwa	Rinderpest	..		...	...	...	...
	Foot-and-mouth disease	196	104	158	...	38	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Haemorrhagic Septicaemia	11	11	...	11	...	...
	Rabies (Dogs)	3	...	...	...	...	3

G. V. S. Office.
Colombo, 14th April, 1934.

M. CRAWFORD,
Government Veterinary Surgeon.

METEOROLOGICAL REPORT

MARCH, 1934

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	85·2	− 3·0	72·5	− 1·4	74	93	6·2	7·57	18	+ 3·05
Puttalam -	87·5	− 2·4	71·4	− 1·2	71	90	4·4	2·96	10	− 0·01
Mannar -	88·1	− 2·3	74·6	− 0·3	73	88	4·4	2·08	3	+ 0·64
Jaffna -	84·7	− 3·7	75·4	+ 0·7	70	86	4·5	0·69	3	− 0·46
Trincomalee -	84·2	− 1·0	75·4	− 1·3	76	88	4·7	5·63	6	+ 3·89
Batticaloa -	84·4	− 0·9	74·3	− 0·7	78	93	5·5	3·96	9	+ 0·79
Hambantota -	84·1	− 3·0	72·7	− 1·3	74	88	4·8	3·45	9	+ 0·89
Galle -	84·6	− 2·3	73·8	− 1·1	78	90	5·8	12·28	18	+ 7·62
Ratnapura -	89·4	− 2·8	71·0	− 1·6	74	95	6·6	7·82	23	− 1·16
A'pura -	88·3	− 2·7	71·3	− 0·3	67	95	6·9	3·25	9	+ 0·34
Kurunegala -	89·0	− 3·8	70·0	− 2·2	68	95	6·4	10·46	12	+ 5·33
Kandy -	84·3	− 3·3	67·5	− 1·3	73	87	5·0	7·97	16	+ 3·78
Badulla -	80·1	− 2·1	63·1	− 1·2	74	97	5·2	5·83	14	+ 1·22
Diyatalawa -	74·8	− 2·4	57·8	+ 0·1	72	91	6·1	10·54	18	+ 6·22
Hakgala -	70·2	− 2·2	51·3	+ 0·3	72	88	5·9	7·09	20	+ 1·51
N'Eliya -	68·4	− 2·5	46·1	0	74	96	6·8	4·07	14	+ 0·59

March rainfall was in excess over the greater part of the Island. Excess was fairly well marked in most of the districts adjacent to the main hill masses, and in the south-western low-country, while elsewhere excess and deficit were generally both slight, excess predominating, except in the extreme north. Only two stations reported excesses above average, in their monthly totals, of over 10 inches, Ambanpitiya (10·42) and Baddegama (10·34).

There were 10 daily falls of 5 inches or more reported, the highest being 8·44 inches, at Batapola, on the 10th-11th.

During the first week of the month there was comparatively little rain, most of which fell in the south-west of the Island as the result of local thunderstorms. For the remainder of the month local afternoon and evening thunderstorms were well developed, and generally gave extensive rain.

Temperatures were nearly everywhere below normal, especially by day Relative humidity was above normal, particularly in the day-time, while cloud was also in excess. Barometric pressure was below normal, and wind strength about normal, while wind directions were variable.

Hail was reported from four places during the month. Blackwater Estate reported a little small hail on the 10th, another fall was reported on the 14th at Maho, while on the 30th hail was reported both from Diyatalawa and from the Kandy road, about 12 miles from Colombo.

H. JAMESON,
Supdt., Observatory.